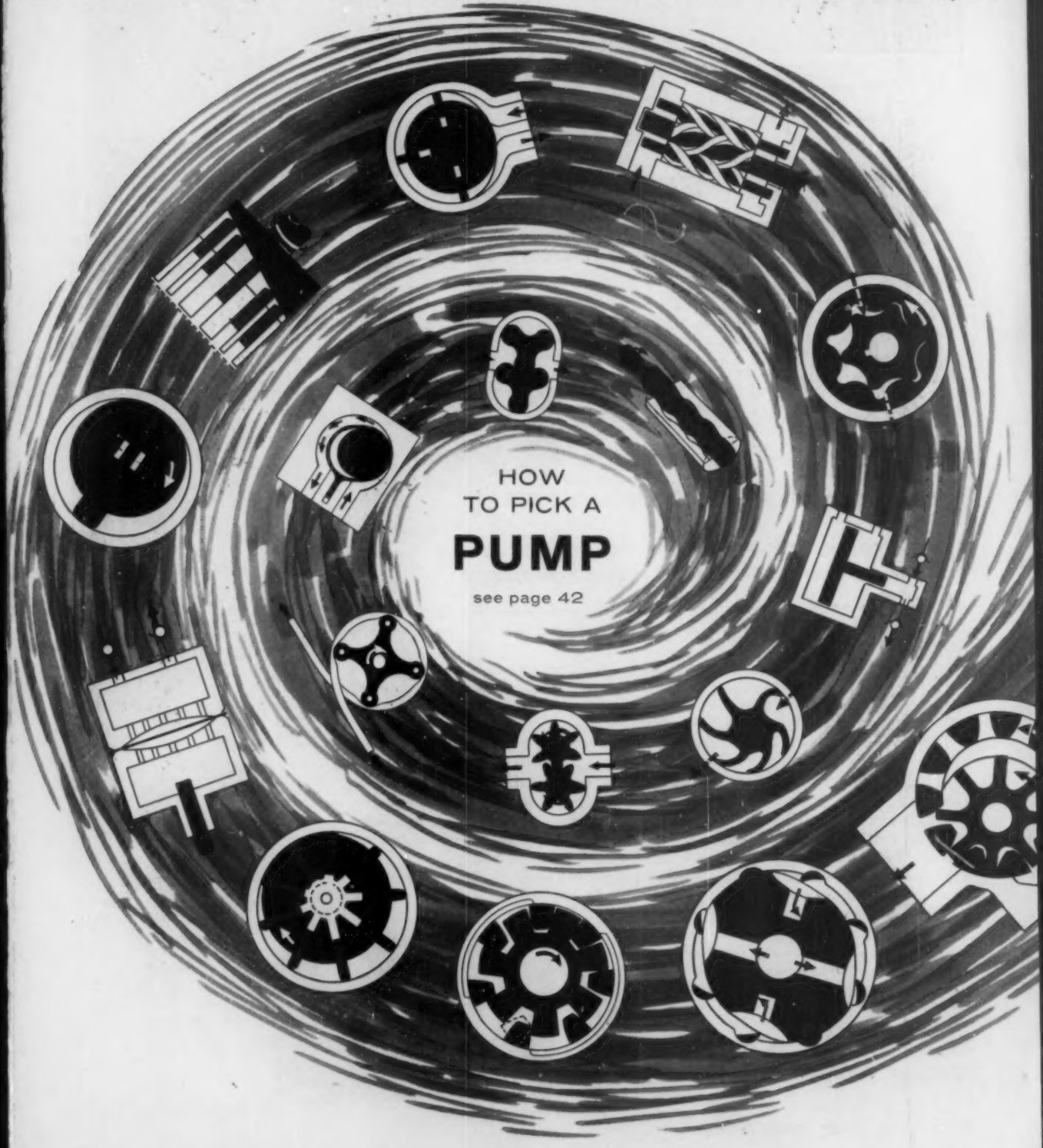
$3 A YEAR

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · JUNE 6, 1960



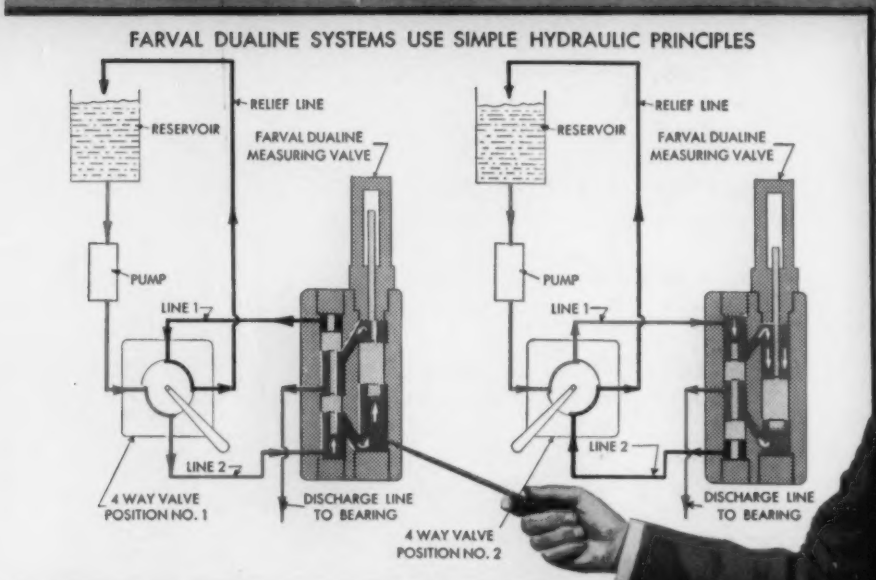
HOW
TO PICK A

PUMP

see page 42

FARVAL
—Studies in Centralized Lubrication
No. 246

"For positive lubrication of large, medium and heavy-duty installations . . . it's a Farval Dualine System!"



With Farval Dualine centralized lubricating systems you get the following distinct advantages over other type systems . . .

(a) Much lower operating pressures with consequently less danger of soap separation on grease systems. Also, less danger of system damage due to high lubricant pressures.

(b) Large lubricant passages with no pinhole ports, ensures practically full pump pressure for every metering valve. This is one of the reasons why Farval Dualine systems operate on lower pressures — give less sieving and working of lubricants.

(c) Positive indication at each bearing — does not have to depend on the questionable action of a single indicator at the pump.

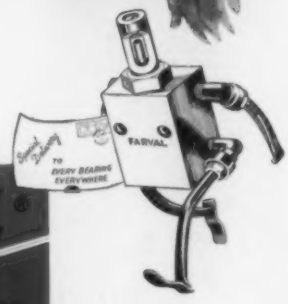
(d) Each metering valve individually adjustable for the requirements of the bearing it serves.

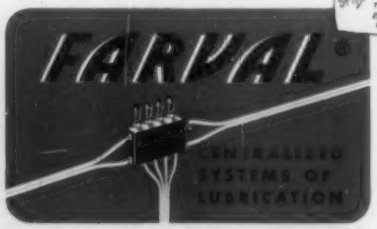
(e) Independent metering valve operation. Should trouble develop with one valve, the system will continue to operate. Only one bearing (not all the bearings) will require hand lubrication until trouble is corrected.

(f) True lubricant metering. Quantity of lubricant delivered to one bearing is not dependent on any other valve in the system.

(g) Much easier to spot and correct trouble.

Check with your Farval Representative and see how these versatile systems can improve production operations — reduce costs. Or write for free Bulletin 26-T containing complete engineering information on Farval Dualine systems.





Farval Division
Eaton Manufacturing Company
3279 East 80th Street • Cleveland 4, Ohio

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

June 6, 1960 Vol. 31, No. 23

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
COMING NEXT WEEK 4
DEVELOPMENTS TO WATCH 6
WHAT'S NEW IN RESEARCH 10
FROM WASHINGTON 12
READER TO EDITOR 14
COMING EVENTS 15
FYI PERSONAL 16
HORIZONS 29
PRODUCT DESIGNS 38
SIGNIFICANT COMPONENTS 56
DESIGN LITERATURE 74
REPRINTS 87
ADVERTISERS INDEX 89
READER SERVICE CARDS 91

REPORT ON THE DESIGN SHOW . . . by the editors of Product Engineering
Eight special pages bring you this double roundup—reporting the panel sessions and evaluating exhibits at the show just closed 17

HOW TO SPECIFY FINISHES FOR MAGNESIUM . . . J Stevens, Dow Metal Products
Guide includes appraisal of chemical treatments and organic coatings . . . 31

INDOCTRINATION OF FLEDGLING ENGINEERS . . . L J Frangipane, Kearfott Co
It's given when this plant slows down for summer vacation 36

CUSTOM KNOBS FROM STANDARD TOOLING . . . R K Gray, Dimco-Gray Co
Special shapes need only inexpensive changes of a standard mold 41

SELECTING POSITIVE-DISPLACEMENT PUMPS . . . Dr W E Wilson
Easy-to-use graphs give values for power, efficiency, suction 42

REINFORCING RINGS ON PRESSURE CYLINDERS . . . R I Isakower
Quick equations find accurate values for the changed stresses 53

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS: **New inks** print circuits directly 8
Viscoelastic damping compound cuts vibration in metal plates 56

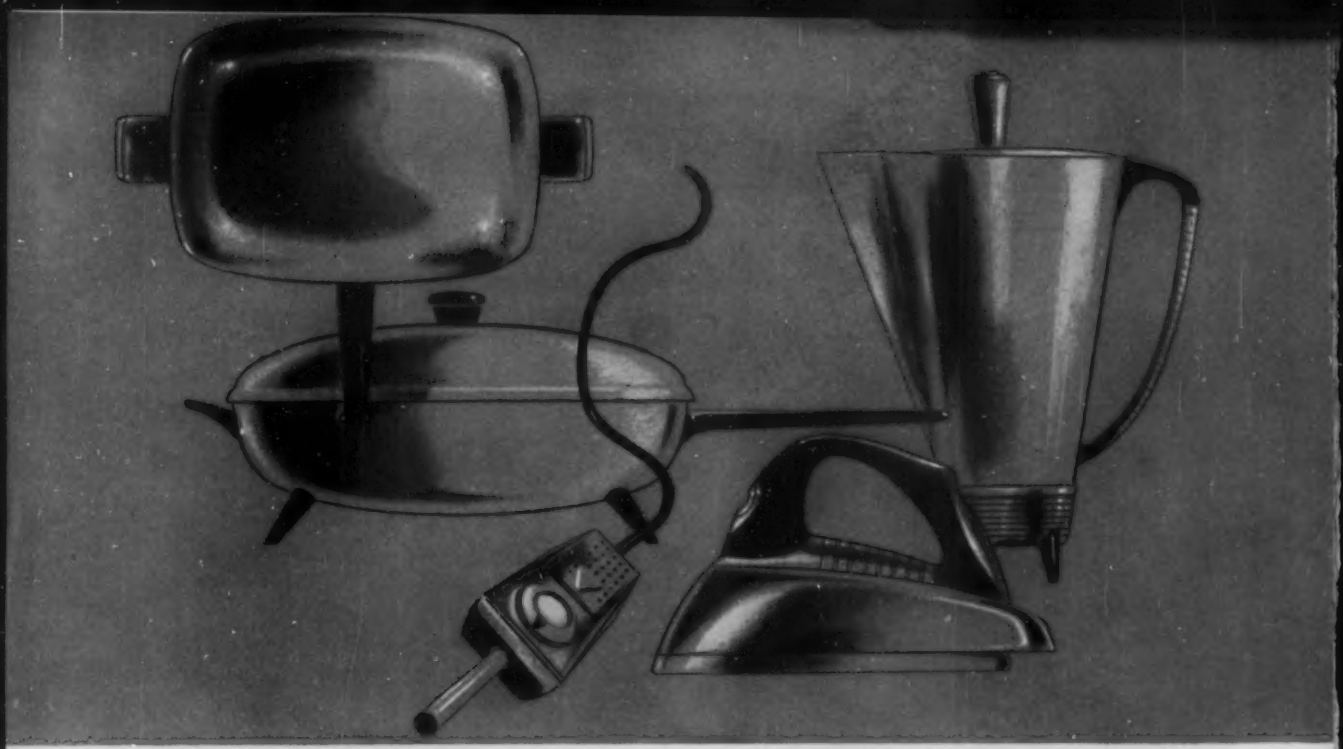
MECHANICAL: **New magnet is smaller,** more efficient 6
Pneumatic level-control monitors either solids or liquids 8
Simpler flowmeter puts taper where it's cheaper 8
Shrinkable steel gasket provides low-temp seal 10

ELECTRICAL: **Electrode endurance** may govern success of space propulsion 10
Electrical heating elements available at 1/3 usual cost 56
Ten-amp rotary limit switch weighs less than 0.16 lb 56

PRODUCTS DESIGN: **An outboard motor** powers this simply designed helicopter 38
Recharging fire extinguisher easy as changing light bulb 40

TESTS: **Antiknock ratings** cause fuel-test problems 10

GENERAL: **Edison and "that mathematical fellow"** 3
Patent subclasses—a rich vein of free ideas 83



STEVENS APPLIANCE THERMOSTATS

- slash lead time
- cut development costs
- are realistically priced

To check rising thermostatic control costs, check up on the Stemco thermostat line *while your product is in the planning stage.* Since the Stemco line is the broadest in the industry, there is a standard production-line Stemco thermostat — or a minor variation thereof — to fill your special requirements *exactly.* That saves design and lead time . . . saves on development costs . . . *gives a proven unit at a realistic cost.*

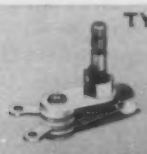
A-954A

STEMCO® THERMOSTATS

STEVENS *manufacturing company, inc.*
P.O. Box 1007, Mansfield, Ohio

Refer to Guide 400EO for U.L. and C.S.A. approved ratings.

TYPE S*.



Adjustable or non-adjustable. Positive-acting, single-stud or nozzle mounting. Operation to 550°F. Rating: 15 amps non-inductive at 115 VAC, 8.3 amps at 240 VAC. Spade or screw terminals. Bulletin 1000.

TYPE G*.

Semi-enclosed and hermetically sealed styles. Independent bimetal disc construction for operation to 300°F. Non-inductive ratings: 15 amps at 120 VAC, 7½ amps at 240 VAC. Bulletin 3500.

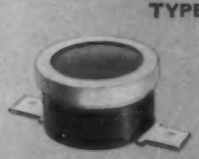
TYPE H.

Positive-acting, adjustable, for fry pans, skillets and other appliances. Fail-safe, open in low to 500°F in high. Rated at 1650 watts at 115 VAC. Bulletin 10,000.

TYPE R*.

Adjustable and non-adjustable styles. Positive acting for operation to 600°F. Rated at 15 amps at 115 VAC, 4 amps at 230 VAC. Screw terminals. Bulletin 7000.

TYPE A*.



Semi-enclosed and hermetically sealed styles. Insulated, electrically independent bimetal disc gives fast response and quick, snap-action control. Operation from -10° to 300°F or higher on special order. Various mountings and terminals. Rated at 13.3 amps non-inductive at 115 VAC. Bulletin 3000.

TYPE SA*.

Adjustable or non-adjustable. Also type SM* manual reset style. Snap-acting with electrically independent bimetal. Also single-pole, double-throw. Non-inductive-load rating 15 amps at 115 VAC, 7½ amps at 230 VAC. Spade or screw terminals; single-stud or nozzle mounting. Bulletin 2000.

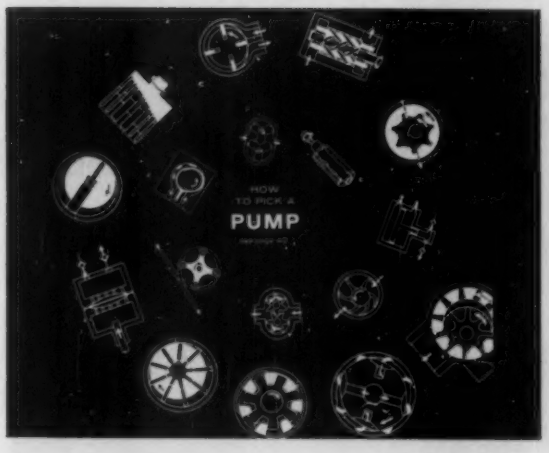
TYPE D*.

For laundry dryers or other surface and warm air applications. Automatic and manual reset types. Snap-acting disc type U.L. approved for operation to 300°F. Rated at 40 amps non-inductive at 120-240 VAC. Open or enclosed styles. Bulletin 8000.

TYPE M.

Semi-enclosed and hermetically sealed styles. Electrically independent bimetal disc type for appliance and apparatus applications from -10° to 250°F. Rating: 8 amps at 115 VAC, 4 amps at 230 VAC and 28 VDC. Virtually any type terminal. Bulletin 6000.

INTERESTING TO NOTE



On our cover—just a few of the dozens of methods used to move fluids. And the article on page 42 shows how charts rather than calculations can estimate the performance of positive-displacement pumps.

But there is another pump worth noting—perhaps the most durable pump we ever use. It runs steadily for about 65 to 70 years and in this time pumps some 400,000 tons of fluid. In the old days there was no way to shut this pump off without ruining the entire machine. Now, however, there are devices that will substitute as a temporary pumping station while the main pump is undergoing service or repairs. Repair it, yes, but no company has ever yet learned how to manufacture the human heart.

Edison and the Math Man

Often the training methods of our schools fail to meet the full requirements of industry, so companies establish elaborate training programs to break in the young graduate. One training setup, that of the Kearfott Div of General Precision Inc, tries to point its young engineers towards the creative approach. How they do it is described on page 36.

When Edison established his research group at Menlo Park, he had no training program. Edison felt he was paying for constructive work and employes' education could be picked up in their own time. He did not insist that his assistants be college graduates. In fact, Edison seemed to prefer men who had spent four years working in a particular field, rather than a "college man."

Edison Laboratory National Monument

Francis Upton

But he did have one valuable "college man" on his staff, Francis R. Upton, a mathematical physicist. Edison particularly enjoyed teasing Upton about the time he "wasted" on mathematics. "After all," the wizard would say sarcastically, "we might as well have one mathematical fellow around, in case we have to calculate something." Several years later, when Edison began working on the incandescent lamp, "some-

PRODUCT ENGINEERING

STANLEY J ALLING *publisher*
ELMER J TANGERMAN *editor*

ROBERT W CARSON *managing editor*
RICHARD M KOFF *assistant managing editor*

ROBERT E ABBOTT *senior associate editor*

JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
FORD PARK *associate editor*
ROBERT PRENTISS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*
DOUGLAS C GREENWOOD *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
PHYLLIS B SWEED *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
CHARLES J LYNCH *assistant editor*

FREDERICK MARICH *assistant editor*
JOHN PRICE *assistant editor*
FRANCIS E HALL *assistant editor*
BRUCE H FRISCH *assistant editor*

FELIX GIORDANO *Detroit*
SETH PAYNE *Washington*

RICHARD E ROOMAN *art director*
E G LOADER *associate art director*
ANGELA M GIACIN *assistant art director*

NORMA J VAN NESS *production supervisor*
LILLIAN M WITHAM *assistant supervisor*

ROBERT E BRUCKNER *consulting editor*
DEXTER KEEZER *director, economics dept*

C C KANE *reader service manager*

McGraw-Hill News Bureaus

JOHN WILHELM *director*
MARGARET RALSTON *assistant*

GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
ARTHUR ZIMMERMAN *Cleveland*
STEWART W RAMSEY *Chicago*
JENNESS KEENE *San Francisco*
KEMP ANDERSON *Los Angeles*
RAY BLOOMBERG *Seattle*
B E BARNES *Atlanta*
MARVIN REID *Dallas*
JOHN TUNSTALL *London*
ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
CURT AGREN *Stockholm*
ERNEST CONINE *Moscow*
MORRIE HELITZER *Bonn*
JIM MORRISON *Bonn*
SOL SANDERS *Tokyo*
JOHN YAMAGUCHI *Tokyo*

A McGRAW-HILL PUBLICATION

June 6, 1960 Vol. 31, No. 23

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N.Y.

PRODUCT ENGINEERING is published weekly — with an additional Design Digest Issue in Mid-September, by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. PUBLICATION OFFICE, 99-129 North Broadway, Albany 1, NY. See Index to Advertisers for directions regarding subscription or change in address.
UNITED STATES subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscriptions $5 per year; foreign $25 per year, payable in advance. Second-class postage paid at Albany, NY, USA. © Copyright 1960 by McGraw-Hill Publishing Company, Inc. All rights reserved.

UNCONDITIONAL GUARANTEE. IF PRODUCT ENGINEERING'S editorial service becomes unsatisfactory for any reason, paid-up subscribers may cancel their subscription on request to our New York office and the proportionate subscription price of any unmailed copies will be refunded.
PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the editor.
POSTMASTER: Please send form 3579 to PRODUCT ENGINEERING, 330 W. 42nd St., New York 36, NY.

←CIRCLE 2 READER SERVICE CARD

STEVENS APPLIANCE THERMOSTATS

- slash lead time
- cut development costs
- are realistically priced

To check rising thermostatic control costs, check up on the Stemco thermostat line *while your product is in the planning stage.* Since the Stemco line is the broadest in the industry, there is a standard production-line Stemco thermostat — or a minor variation thereof — to fill your special requirements *exactly.* That saves design and lead time . . . saves on development costs . . . *gives a proven unit at a realistic cost.*

A-965A

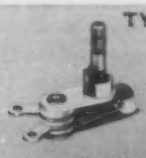
STEMCO®

STEVENS *manufacturing company, inc.*
P.O. Box 1007, Mansfield, Ohio

Refer to Guide 400EO for U.L. and C.S.A. approved ratings.

THERMOSTATS

TYPE S*.



Adjustable or non-adjustable. Positive-acting, single-stud or nozzle mounting. Operation to 550°F. Rating: 15 amps non-inductive at 115 VAC, 8.3 amps at 240 VAC. Spade or screw terminals. Bulletin 1000.

TYPE G*.

Semi-enclosed and hermetically sealed styles. Independent bimetal disc construction for operation to 300°F. Non-inductive ratings: 15 amps at 120 VAC, 7½ amps at 240 VAC. Bulletin 3500.

TYPE H.

Positive-acting, adjustable, for fry pans, skillets and other appliances. Fail-safe, open in low to 500°F in high. Rated at 1650 watts at 115 VAC. Bulletin 10,000.

TYPE R*.

Adjustable and non-adjustable styles. Positive acting for operation to 600°F. Rated at 15 amps at 115 VAC, 4 amps at 230 VAC. Screw terminals. Bulletin 7000.

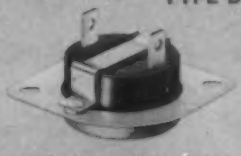
TYPE A*.

Semi-enclosed and hermetically sealed styles. Insulated, electrically independent bimetal disc gives fast response and quick, snap-action control. Operation from -10° to 300°F or higher on special order. Various mountings and terminals. Rated at 13.3 amps non-inductive at 115 VAC. Bulletin 3000.

TYPE SA*.

Adjustable or non-adjustable. Also type SM* manual reset style. Snap-acting with electrically independent bimetal. Also single-pole, double-throw. Non-inductive-load rating 15 amps at 115 VAC, 7½ amps at 230 VAC. Spade or screw terminals; single-stud or nozzle mounting. Bulletin 2000.

TYPE D*.

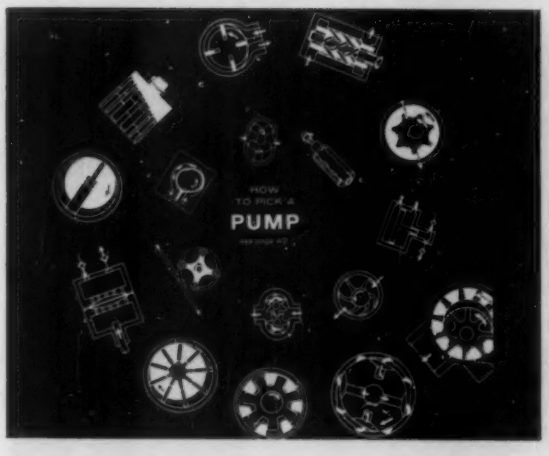


For laundry dryers or other surface and warm air applications. Automatic and manual reset types. Snap-acting disc type U.L. approved for operation to 300°F. Rated at 40 amps non-inductive at 120-240 VAC. Open or enclosed styles. Bulletin 8000.

TYPE M.

Semi-enclosed and hermetically sealed styles. Electrically independent bimetal disc type for appliance and apparatus applications from -10° to 250°F. Rating: 8 amps at 115 VAC, 4 amps at 230 VAC and 28 VDC. Virtually any type terminal. Bulletin 6000.

INTERESTING TO NOTE



On our cover—just a few of the dozens of methods used to move fluids. And the article on page 42 shows how charts rather than calculations can estimate the performance of positive-displacement pumps.

But there is another pump worth noting—perhaps the most durable pump we ever use. It runs steadily for about 65 to 70 years and in this time pumps some 400,000 tons of fluid. In the old days there was no way to shut this pump off without ruining the entire machine. Now, however, there are devices that will substitute as a temporary pumping station while the main pump is undergoing service or repairs. Repair it, yes, but no company has ever yet learned how to manufacture the human heart.

Edison and the Math Man

Often the training methods of our schools fail to meet the full requirements of industry, so companies establish elaborate training programs to break in the young graduate. One training setup, that of the Kearfott Div of General Precision Inc, tries to point its young engineers towards the creative approach. How they do it is described on page 36.

When Edison established his research group at Menlo Park, he had no training program. Edison felt he was paying for constructive work and employes' education could be picked up in their own time. He did not insist that his assistants be college graduates. In fact, Edison seemed to prefer men who had spent four years working in a particular field, rather than a "college man."

Edison Laboratory National Monument

Francis Upton

But he did have one valuable "college man" on his staff, Francis R. Upton, a mathematical physicist. Edison particularly enjoyed teasing Upton about the time he "wasted" on mathematics. "After all," the wizard would say sarcastically, "we might as well have one mathematical fellow around, in case we have to calculate something." Several years later, when Edison began working on the incandescent lamp, "some-

PRODUCT ENGINEERING

STANLEY J ALLING *publisher*
ELMER J TANGERMAN *editor*

ROBERT W CARSON *managing editor*
RICHARD M KOFF *assistant managing editor*

ROBERT E ABBOTT *senior associate editor*

JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
FORD PARK *associate editor*
ROBERT PRENTISS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*
DOUGLAS C GREENWOOD *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
PHYLLIS B SWEED *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
CHARLES J LYNCH *assistant editor*

FREDERICK MARICH *assistant editor*
JOHN PRICE *assistant editor*
FRANCIS E HALL *assistant editor*
BRUCE H FRISCH *assistant editor*

FELIX GIORDANO *Detroit*
SETH PAYNE *Washington*

RICHARD E ROOMAN *art director*
E G LOADER *associate art director*
ANGELA M GIACIN *assistant art director*

NORMA J VAN NESS *production supervisor*
LILLIAN M WITHAM *assistant supervisor*

ROBERT E BRUCKNER *consulting editor*
DEXTER KEEZER *director, economics dept*

C C KANE *reader service manager*

McGraw-Hill News Bureaus

JOHN WILHELM *director*
MARGARET RALSTON *assistant*

GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
ARTHUR ZIMMERMAN *Cleveland*
STEWART W RAMSEY *Chicago*
JENNESS KEENE *San Francisco*
KEMP ANDERSON *Los Angeles*
RAY BLOOMBERG *Seattle*
B E BARNES *Atlanta*
MARVIN REID *Dallas*
JOHN TUNSTALL *London*
ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
CURT AGREN *Stockholm*
ERNEST CONINE *Moscow*
MORRIE HELITZER *Bonn*
JIM MORRISON *Bonn*
SOL SANDERS *Tokyo*
JOHN YAMAGUCHI *Tokyo*

PRODUCT ENGINEERING is published weekly — with an additional Design Digest issue in Mid-September, by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. PUBLICATION OFFICE, 99-129 North Broadway, Albany 1, NY. See Index to Advertisers for directions regarding subscription or change in address.
UNITED STATES subscription rates for individuals in the field of the publication, $3 per year, single copies 50 cents; Canadian subscriptions $5 per year; foreign $25 per year, payable in advance. Second-class postage paid at Albany, NY, USA. © Copyright 1960 by McGraw-Hill Publishing Company, Inc. All rights reserved.

A McGRAW-HILL PUBLICATION

June 6, 1960 Vol. 31, No. 23

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N.Y.

UNCONDITIONAL GUARANTEE. IF PRODUCT ENGINEERING'S editorial service becomes unsatisfactory for any reason, paid-up subscribers may cancel their subscription on request to our New York office and the proportionate subscription price of any unmailed copies will be refunded.
PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the editor.
POSTMASTER: Please send form 3579 to PRODUCT ENGINEERING, 330 W. 42nd St., New York 36, NY.

←CIRCLE 2 READER SERVICE CARD

thing" came up. He found Upton's mathematical background invaluable in computing resistance in circuitry. Although Edison never admitted it, he must have gained some respect for men like Upton, who "wasted" time studying mathematics and physics in universities.

Where's the Fire?

When electric motors were first used to power machines, one of the hazards was fire. (Even today electrical fires cause more than $100 million damage annually.) For centuries, water was a cure-all for any type of conflagration, but when used to extinguish a blaze caused by electric circuitry, it often meant electrocution for the unfortunate fireman. Soon, red pails filled with sand became a familiar sight in factories and plants throughout the country, but the problem of fire still existed—sand will control a small blaze but is ineffective for one of any size.

Then about 1906, a Scotsman, Peter G. MacGregor, devised a portable fire extinguisher that worked better than anything on the market. MacGregor, a tool worker, had only one arm, but he learned to use his knee and foot in lieu of his lost limb. His device was very simple: A tin cylinder filled with a vaporizing liquid (probably carbon tetrachloride), and a simple piston pump with a workshop chisel as a handle. For a nozzle he used the spout from his wife's sewing-machine oilcan. His simple extinguisher did an effective job—the nonflammable chemical vaporized, displaced the oxygen in the air, and put out the fire. In 1907, MacGregor left the tool business and formed his own company to market his extinguisher under the trade name Pyrene (from the Greek word pyros meaning "fire"). MacGregor's first model had one disadvantage. It could not be refilled in a hurry. Now, as the article on page 40 describes, there is a dry-powder fire extinguisher that can be recharged in seconds.

—Benedict A. Leerburger Jr

SIDELIGHTS

After four days at New York's Coliseum covering the Design Engineering Show (p 17) we thought we had seen every facet of engineering. But upon returning to the office, we glanced through the employe bulletin of the Oregon Dept of Agriculture and discovered the following:

"The dairy cow is a mobile, animated machine housed in unprocessed leather. One end is equipped with a mower, grinder, and other standard equipment including bumpers, headlights, wingflaps and foghorn. At the other end is a milk dispenser and insect repeller. Centrally located is a conversion plant consisting of a combination storage and fermentation vat, three converters in series, and an intricate arrangement of conveyor tubes. This machine is also equipped with a central heating plant, pumping system and air conditioning. It is available in various sizes, colors and output capacity ranging from 1 to 20 tons of milk a year."

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Corner Construction for Joining Sandwich Panels**
Evolution of a design that resists rough handling and reduces cost and weight.

. . . **New Standards Needed for Motor Protection**
Sefeguards can be simpler now, thanks to small detectors that monitor temperatures in the motor windings.

. . . **How to Choose the Right Solder Flux**
An up-to-date selection guide based on chemical origin, and covering all the significant types.

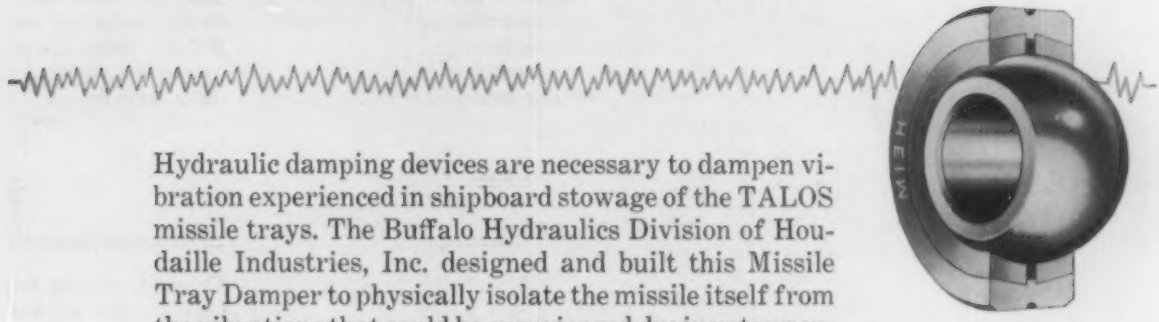
. . . **Epicyclic Gear Systems**
Systematic analysis of volume, power capacity, speed ratios and stresses.

. . . **Problems and Possibilities in Product Development**
New materials, new production methods, and new methods of analysis and design have greatly increased the engineer's reach.

. . . **Escapement Mechanisms**
Six ways to obtain such action.

To Eliminate Vibration

in Missile Trays Stored in Naval Vessel Missile Magazines.



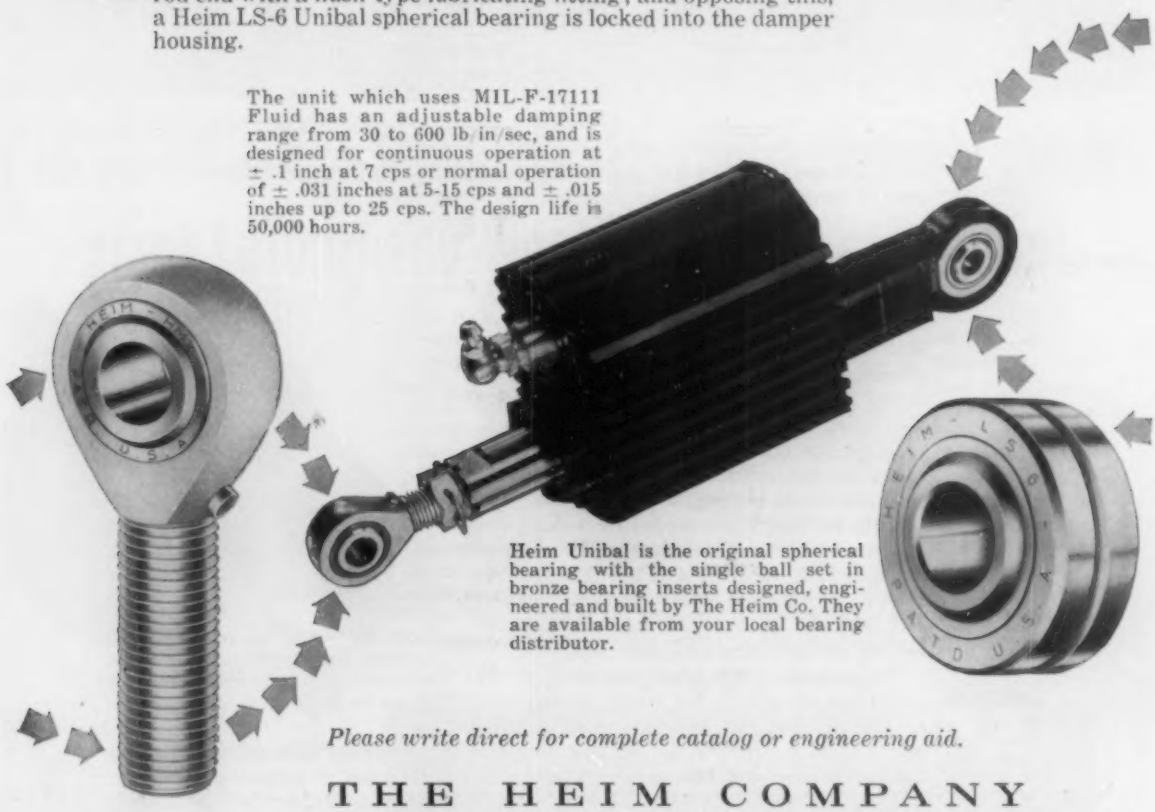
Hydraulic damping devices are necessary to dampen vibration experienced in shipboard stowage of the TALOS missile trays. The Buffalo Hydraulics Division of Houdaille Industries, Inc. designed and built this Missile Tray Damper to physically isolate the missile itself from the vibrations that could be experienced during stowage.

With the misalignment which can be expected of equipment used on shipboard it was necessary to use a reliable, inexpensive self-aligning rod end such as

HEIM *Unibal*® SPHERICAL BEARING

At one end of the damper is a male threaded HMX-6FG Heim rod end with a flush-type lubricating fitting; and opposing this, a Heim LS-6 Unibal spherical bearing is locked into the damper housing.

The unit which uses MIL-F-17111 Fluid has an adjustable damping range from 30 to 600 lb/in/sec, and is designed for continuous operation at ± .1 inch at 7 cps or normal operation of ± .031 inches at 5-15 cps and ± .015 inches up to 25 cps. The design life is 50,000 hours.



Heim Unibal is the original spherical bearing with the single ball set in bronze bearing inserts designed, engineered and built by The Heim Co. They are available from your local bearing distributor.

Please write direct for complete catalog or engineering aid.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

DEVELOPMENTS TO WATCH . . .

Research improves rubber parts

Better mechanical rubber goods are forecast by two developments announced by Britain's Natural Rubber Development Board.

One is a processing aid that promises use of the lower grades of rubber in parts where such low-cost materials have not previously been satisfactory.

The other is a compounding system that extends the low-temperature utilization limit of natural rubber at least to −75 F.

The new processing aid, named PA 80, is said to permit producing natural rubber parts of very low hardness, and low-cost extrusions that show good retention of such physical properties as compression-set. Furthermore, says the NRDB, PA 80 improves the processing of general-purpose synthetic rubber "to a degree quite unobtainable with a similar amount of ordinary natural rubber," and produces parts with unusual smoothness and dimensional accuracy.

As to the cold-resistant compounds, NRDB says they seem particularly promising for vibration mountings, suction cups, cold-chamber window seals, and similar parts.

New magnet is smaller, more efficient

An improved shading-coil magnet has been developed at U of Wisconsin and is now under test at Allen-Bradley Co. It's an ac type that has a shorted turn (the "shading" coil or ring) surrounding a portion of the pole, the aim being to delay the change in its magnetic flux and thus minimize or prevent contact "chatter."

As H. J. Kubiak of Wisconsin points out, "The ideal shading-coil magnet would exert a constant, silent force on the armature; that is, it would operate like a direct-current magnet. In the ideal magnet, the shaded and unshaded pole-face areas would be equal. Their fluxes would be equal in magnitude, vary sinusoidally with time, and would be exactly 90° out of phase."

The new design, which introduces a constant reluctance (by providing a slit with an airgap) in the path of the flux that appears at the unshaded pole-face of the magnet, comes very close to this ideal. Flux in the shaded and unshaded poles can be made equal, with a phase angle of 80°.

With the new design, it is also claimed, magnet size can be reduced; and a reduced ratio of maximum to minimum force helps minimize noise.

Low-cost cushion roller designed in Austria

A roller that's simply a steel cylinder fitted lengthwise with a steel axle mounted in a ball-bearing, plus a rubber ring and two steel rings, promises shock resistance at low cost. It's designed for use in conveyors and for mounting connecting rods and other mechanical parts.

In the new unit (see illustration) the cylinder serves as the outer housing, and the axle, mounted on its bearing, is placed inside. The bearing, in turn, is surrounded by 3 rings, one rubber and two steel, as shown. They are so arranged that, when the nuts are tightened, the rubber ring is pressed tightly against the cylinder wall and the bearing housing, centering the bearing and providing a leaktight seal.

ABC ROLLER consists of steel cylinder, axle, bearing, and 3 rings, assembled and tightened by nuts shown in foreground.

Provision for a slight axial movement of the axle helps compensate for errors in placement of the axle and for operational shocks. Simplicity of the design, plus the fact that the inside of the cylinder does not need machining, makes possible a relatively shock resistant, noise-free unit at surprisingly low cost.

The ABC (Austrian Binder Cushion) roller is to be made commercially by Ludwig Binder & Co, Graz, Styria Province.

BLOOD BROTHERS jointed steering assembly guides giant LeTourneau-Westinghouse coal hauler!

No matter how large the equipment you design, there's a Blood Brothers steering or jointed driving assembly big enough to do the job. One example of the use of Blood Brothers components on large equipment is the L6S Steering Assembly on the LeTourneau-Westinghouse Haulpak Coal Hauler.

This mammoth, highly maneuverable "mountain mover" is a bottom-dump 450 h.p. diesel unit that weighs 37 tons. Yet it carries 2½ *times* its own weight in payload, or the equivalent capacity of over one and one-half standard 50-ton railroad cars!

Rockwell-Standard's Universal Joint Division offers you a wide range of specialized engineering experience—involving everything from manual steering assemblies . . . to power take-off drives . . . to heavy-duty propeller shafts. Whatever size and type equipment you manufacture, Rockwell-Standard can save you time, money – help you achieve higher standards of performance. Let us prove it—on your project!

Write for complete information

Another Product of...

ROCKWELL-STANDARD
CORPORATION

ROCKWELL R STANDARD

Universal Joint Division, Allegan, Michigan

CIRCLE 7 ON READER SERVICE CARD

Simplified flowmeter puts taper where it's cheaper

A flowmeter designed in Britain eliminates the costly, hard-to-make internally tapered glass calibration tube. It substitutes a straight-bored tube in which is a tapered rod.

The tube serves as the fluid-carrier, and the rod, with taper on the outside, carries the ring-shaped float—which is free to move up or down as flow speed increases or decreases.

This, says United Kingdom Atomic Energy Authority (holder of the patent), not only simplifies manufacture—since a metal rod with external taper is far easier to make than a glass tube with internal taper—but also makes the flowmeter easier to use.

With the conventional type, it is difficult to apply heat (to handle viscous liquids, for instance) since the heating jacket must be so designed that it will not obscure the graduations on the tube walls.

In the new design, heat can be applied simply by passing an electric current through the tapered metal rod, or by using a hollow rod containing an electrical heating element.

New inks print circuits directly

New electroconductive printing inks offering a considerable range of electrical properties have been developed by Sinclair and Valentine Co, and are now being field tested. These are inks with sufficient conductivity to permit direct printing of electrical circuits —without complex plating or screening processes—with substantial reductions in circuit costs for many mass-production applications. Among the types now under test are moisture-set black inks with resistances (measured at $\frac{1}{8}$-in. electrode distance) of 2,000-40,000 ohms; heatset black at 5,000 to 50,000; and silver (moisture-set and heatset) with a resistance range of 50 to 500.

S & V emphasizes that these readings apply only when the ink is deposited as a continuous film. On porous surfaces, where continuous films may be harder to achieve, results may not be as good.

Electrical shock waves to shape metal

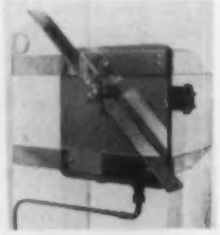
Forming by electrical explosions—under water—is now being investigated by at least five companies as a means for shaping the intractable metals. The technique is similar in most respects to the widely publicized methods that use high-explosive chemical compounds. But researchers using the newer capacitor-discharge techniques hope they'll be able to get around many of the problems that arise in handling the chemicals.

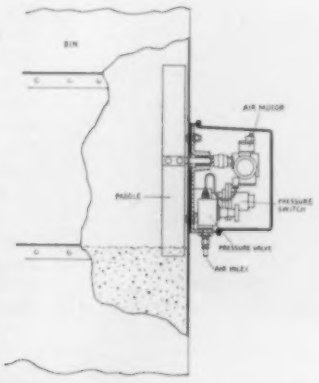
Air-operated level-control designed in Britain

For use where electrical circuits are dangerous or undesirable, Henry Simon Ltd of Cheshire, England has come up with a pneumatic level-control that will monitor either solids or liquids.

Inside the housing (see diagram) the unit has a pressure valve, an air switch, and an air motor. The latter is connected by a spindle to a paddle located outside.

The unit is so designed that the paddle oscillates continuously under air pressure until or unless it is covered by the solid or liquid. When it is, the oscillation is hampered and a control device, signal or alarm is activated.

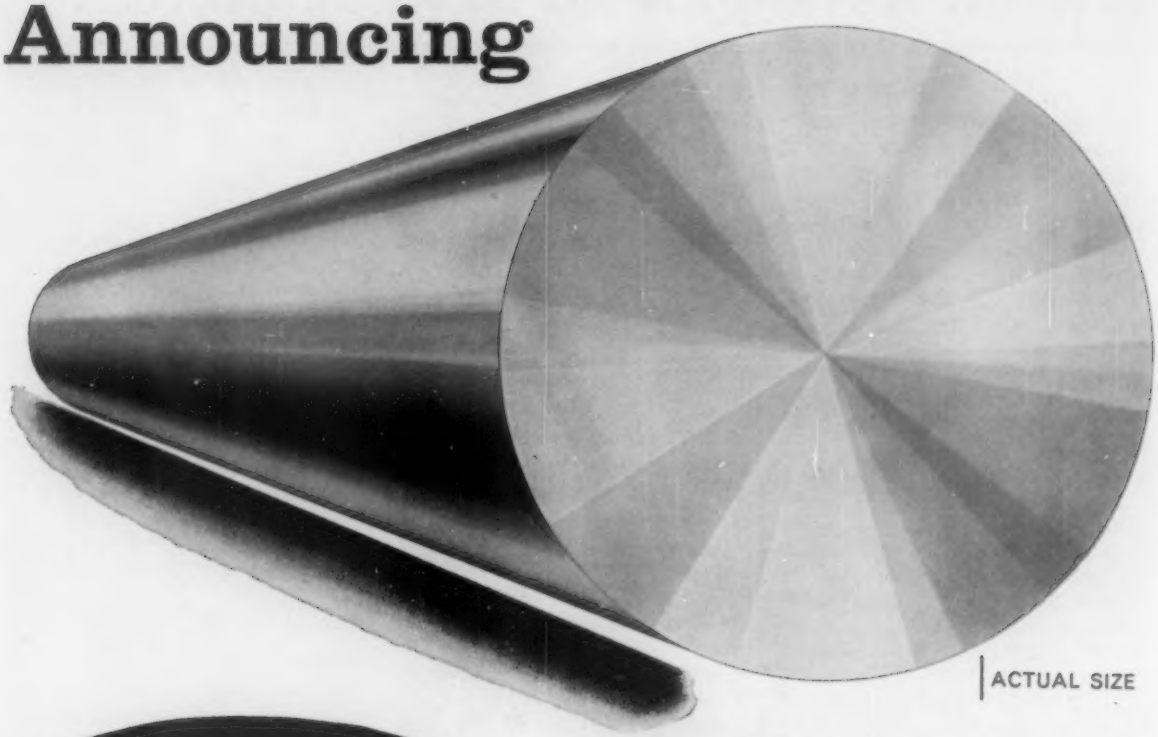




LEVEL-MONITORING UNIT is air-operated, can be mounted through roof or wall of bin or tank, as shown here.

In the standard unit, the housing is about 9 in. square; the paddle 16 in. long.—ARG

Announcing



ACTUAL SIZE

STRESSPROOF®
STEEL BARS
WITH COPPER

In Diameters Through 4"

Five new sizes: 4", 3⅞", 3¾", 3⅝", 3½".

Same high strength as smaller diameters...100,000 psi yield.

Fast machining...83% of B1112.

Cost less than heat treated in-the-bar alloys.

Ideal for both production *and* maintenance applications.

No heat treating necessary

Available from your
Steel Service Center

Ask for Helpful Data Bulletin #15.
It tells the story of STRESSPROOF.

La Salle STEEL CO.

1430 150th Street
Hammond, Indiana

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

CIRCLE 9 ON READER SERVICE CARD 9

WHAT'S HAPPENING IN RESEARCH . . .

Rating problems in fuel tests

Antiknock ratings can be misleading, say W. E. Adams and J. D. McCullough of Ethyl Corp—particularly where higher octane fuels are concerned (Motor octane ratings above 95; Research ratings above 98). Reproducibility of ratings from one laboratory to another becomes progressively poorer, they say, as octane levels increase. Primary trouble: the multiplicity of variables that enter into the test (they've isolated at least 8), with knockmeter pickups causing the most trouble.

In a report to the American Petroleum Institute, they say: "The results showed that differences in the performance of knockmeter pickups affected knock ratings more than other variables by a factor of four times." Furthermore, "incomplete compensation for barometric pressure changes, by the current method, exceeded the average of six other factors by three times."

Permissible differences in engine speed alone (the Research method specifies a speed of 600 ±6 rpm) can make a difference of as much as 0.12 in the Research octane number; tolerances in air temperature (±2° F) can introduce an "error" of 0.01; cylinder-height tolerances (±0.025 in.) can make an additional difference of as much as 0.16.

Other factors that must be considered: fuel-air ratio, ignition timing, quantity of lubricant (type is less important), and the instrumentation itself—particularly the pickup used in the knockmeter—a suppressed-zero, time-averaging type of peak voltmeter.

GOLD-PLATED PISTON helps Shell Research Ltd study engine deposits. Noble metal was chosen to minimize deposit adhesion, and results confirmed belief that deposits are considerably less adherent to surfaces not susceptible to pitting.

Shrinkable steel gasket provides low-temp seal

A glass-to-metal seal for liquid hydrogen that's said to improve in performance as it is used has been designed by Lawrence Radiation Laboratory scientists. It was devised to minimize leakage around the frame of the optical window in a big (72 in.) glass bubble chamber.

The seal consists of an indium ring and a shrinkable stainless steel gasket, and it takes advantage of the ability of indium to retain its softness at very low temperatures (which lead does not), and of the difference in shrinkage between metal and glass. As the assembly is cooled to liquid-hydrogen temperature, the steel shrinks about ⅛ in. more than the glass, gripping the indium tightly. Then, relatively light pressure (about 500 psi) is applied to mash the indium and make the seal.

The system is not perfect, but good enough so vacuum pumps can handle what leakage there is; and, say Lawrence researchers, the seal stands up well under pulsing. In fact, after an initial period of chamber pulsing, the seal has actually been found to improve.

Electrodes may be key to space propulsion

Electrode endurance, rather than basic technology or engine design, may be the governing factor in development of plasma jet electric rockets for outer space, a report from NASA indicates.

In the plasma jet engine types under discussion, liquid hydrogen would be passed through an electric arc that would heat it to 4000 F. It would then spurt out through the rocket nozzle, producing the propelling thrust.

The big problem, says NASA, is to find electrode materials and an electrode design that will permit the unit to operate reliably for two months or more. The time factor is particularly important since engines of this type, though three or four times as efficient as chemical propulsion systems, do not have thrust-to-weight ratios low enough to make them suitable as launching engines. They are at their best for long-range use in outer space, and would be installed in a space craft to be turned on when the craft is in orbit—to power it on deep space missions.

briefs . . .

New lab recorder that will chart "any instrument reading that can be converted into dc millivolts in its range" is offered by Fisher Scientific Co. It's line-operated, 15x13x9 in., weighs 28 lb, has a choice of 5 speeds with "gear shift" control. Price: $850.

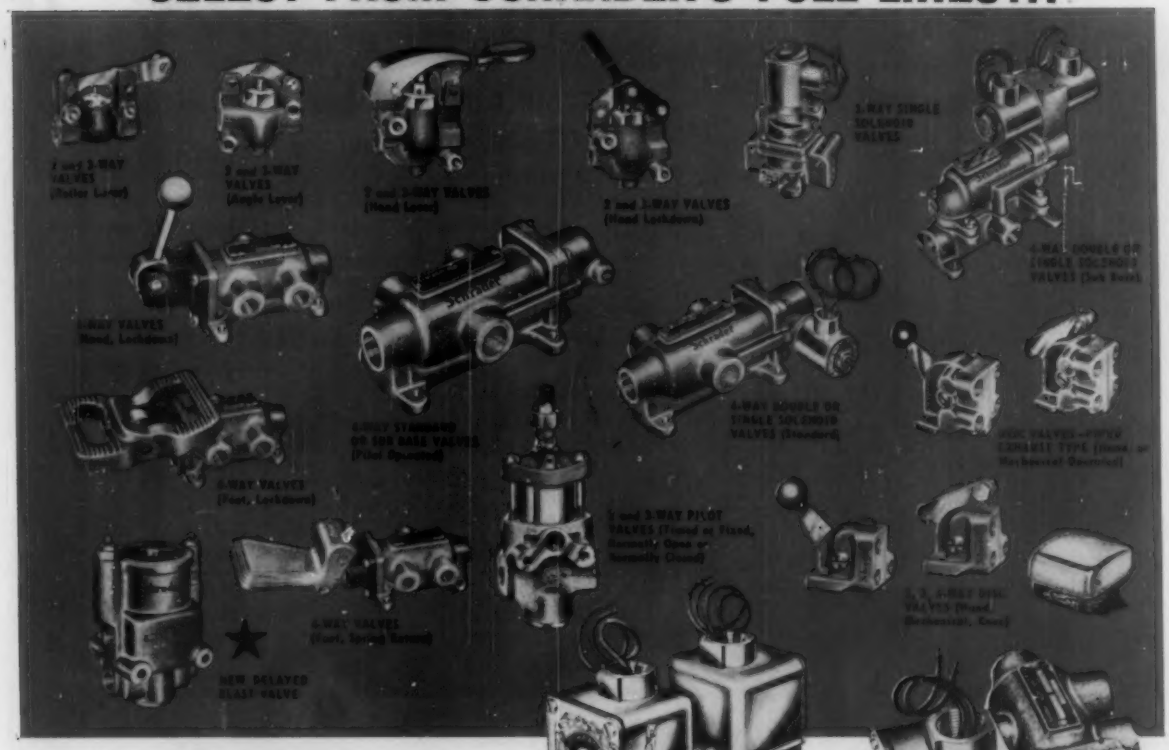
Diffusion bonding, as an old-but-new way to join parts without melting or massive deformation, is discussed in a report from Defense Metals Information Center.

In its broadest interpretation, this term includes such varied processes as pressure welding, flash welding, fusion welding, brazing, and soldering. But, today, the term is being more strictly applied. A process is considered to be diffusion bonding only if it is a joining technique by which coalescence of clean, closely fitting parts is obtained primarily by applying pressure. No melting and no measurable deformation should result.

Under this definition fall such processes as hot-pressure bonding, gas-pressure bonding, solid-phase bonding, and diffusional bonding.

Says DMIC: In simple terms, the only requirement for diffusion, or any type of bonding, is to bring the mating clean surfaces close enough together to permit their interatomic attractive forces to become effective. —ARG

SELECT FROM SCHRADER'S FULL LINES...



...TO IMPROVE PERFORMANCE OF ANY OPERATION

...TO UPGRADE PRODUCTION

SUB-BASE available in single solenoid, 4-way; double solenoid, 4-way.

STANDARD BASE available in single solenoid, 3-way; single solenoid, 4-way; double solenoid, 4-way.

New JIC Solenoid Valves are compact, rugged, fast-and-easy to install. Roomy junction boxes fit space requirements with 90° rotation. Can be operated in case of current failure, by hand. Safe, recessed override button prevents accidental operation. Electrical system completely sealed against dust, oil.

Schrader's complete line of air valves allow you a freer hand in planning air circuits for your applications. Besides almost unlimited choice of size, style and actuation method, you get these extras in every Schrader valve you buy:

- All parts are designed for maximum air flow, longest service life; simplicity of replacement; interchangeability.
- Schrader Valves feature tough, practical design, precision construction, and are individually tested to full ratings.
- Performance has been proved by years of use in hundreds of plants. All Schrader Valves can operate with Schrader (JIC) Square End Cylinders perfectly.

Use the full Schrader line to do your air control selecting. Your Schrader distributor can help you pinpoint what you need. For more data write:

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
477 Vanderbilt Avenue, Brooklyn 38, N. Y.

Schrader®
a division of SCOVILL

QUALITY AIR CONTROL PRODUCTS

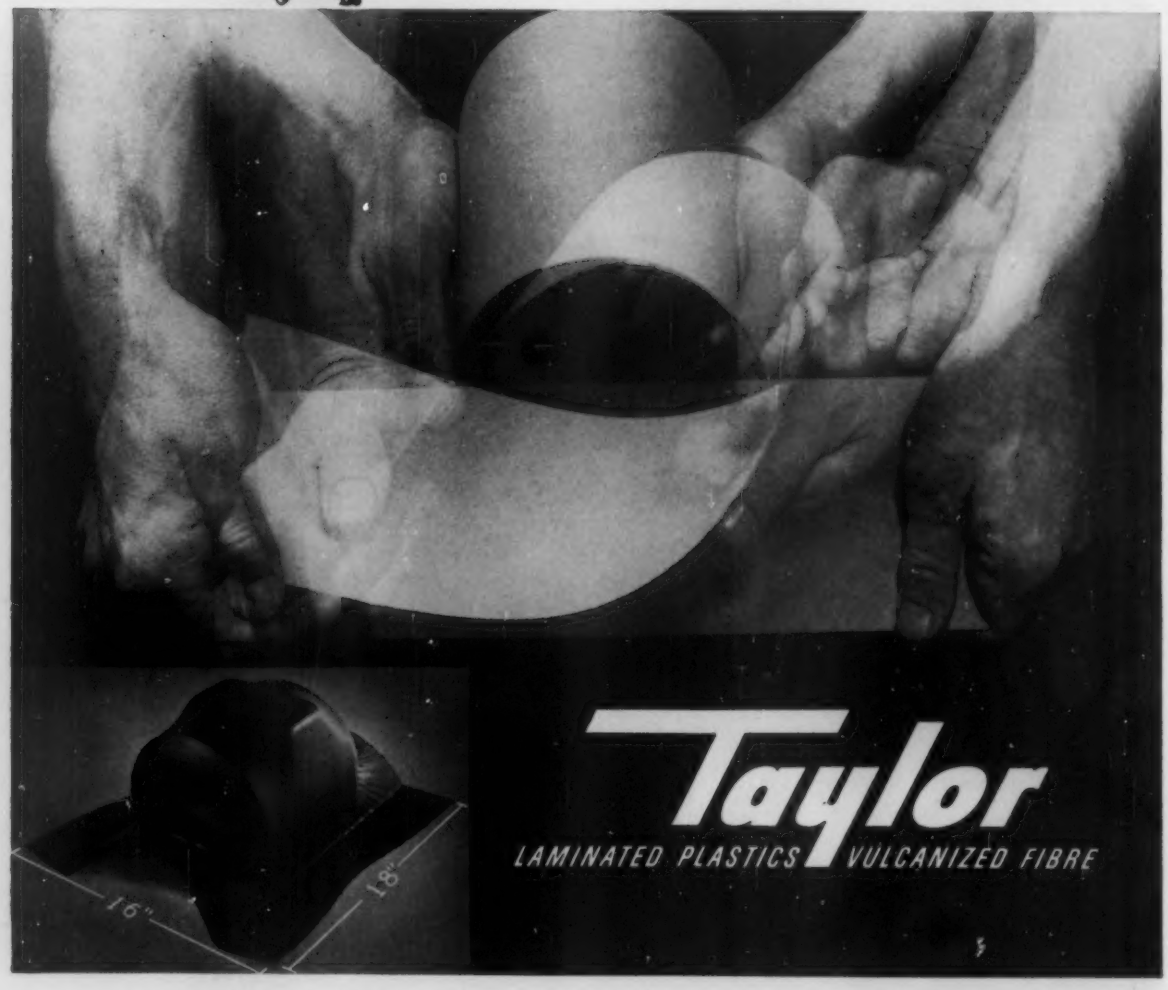
New "Taylorite"® is a veritable workhorse

Improved Vulcanized Fibre has the formability and strength to be deep drawn into many intricate shapes

There has been a big change in Taylor Vulcanized Fibre, including the name. New processing equipment and atmosphere-controlled storage facilities have enabled us to make major advances in overall reliability—including uniformity from lot to lot—at no increase in cost to you. Among the improvements are better formability and capacity to be deep drawn. These, combined with greater tensile strength, flexural strength and dielectric strength, make new Taylorite an ideal material for 1001 industrial applications.

Samples are available. Test them for yourself. Put them under tension, flex them, compress them, form them. You will find that new Taylorite survives your severest tests. And remember, Taylor offers complete design and engineering service. Write for Data Sheet 2-0 and samples. Taylor Fibre Co., Norristown 39, Pa.

TAYLORITE vulcanized fibre meets deep draw requirements. Material used was .060 in. thick sheet of commercial grade. Forming of the welder's helmet was performed under normal production conditions.



IMPERIAL
Engineering and Data File

DURA-TITE TABLE OF COMPARISON

Features	TYPE OF PORT SEAL		
	Pipe Thread	"O" Ring	Dura-Tite
Permits angular positioning of fitting with no possibility of leaking	no	yes	yes
Suitable for use with all hydraulic fluids without changing components	yes	no	yes
Safety from seepage up to 20,000 psi	no	no	yes
Can be reconnected repeatedly without changing sealing element	no	no	yes
Withstands high pressures to temperatures of 300° F	no	no	yes
Simple to install — no loose parts	yes	no	yes
Usable with SAE standard straight thread boss	no	yes	yes
Unlimited shelf life	yes	no	yes
No deterioration of sealing element due to aging	yes	no	yes
No possibility of damaging sealing element in assembly	yes	no	yes

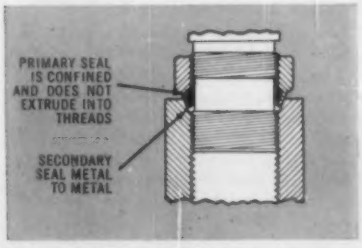
HOLDS PRESSURES TO 20,000 PSI...

NEW DURA-TITE IS INDUSTRY'S MOST FOOLPROOF PORT SEAL FOR TUBE FITTINGS!

From Imperial research comes a new, more effective and far more simplified port sealing method for tube fittings. As you can see on the chart pictured above, Dura-Tite does everything an "O" ring fitting will do—*and much more*—without requiring any special skill or care.

Even at pressures up to 20,000 psi, Dura-Tite provides a positively seepproof seal, and the fitting can be positioned in any direction without impairing tightness. And, because Dura-Tite's polyamide split ring seal is confined, it cannot distort or extrude into threads. The joint can be opened and remade at least 25 times without seepage.

Note how Dura-Tite creates a *double seal* with a single, simple operation. The fitting comes complete, with no additional parts to be added in the field. It uses any standard SAE straight-thread port. No special machining is required.



The special polyamide sealing medium contained in Dura-Tite will outperform any "O" ring compound. It has no hydraulic fluid limitations, being highly resistant to most chemicals. Solves temperature problems, too. Tests have shown that the Dura-Tite seal will withstand high pressures at temperatures up to 300° F. There is no need for periodic replacement because of deterioration on the job.

Dura-Tite port seals can be obtained in both Imperial Hi-Seal flareless and 37° flared tube fittings in steel and stainless steel. And, Dura-Tite costs no more than "O" ring seals but makes important savings in installation.

IT'S IN THE BOOK

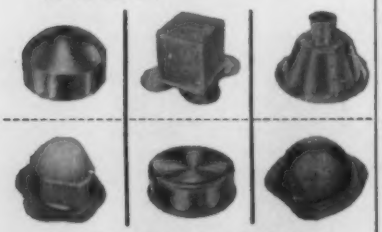
Dura-Tite port seals are covered in Imperial's new Hi-Seal catalog No. 3108 and in Bulletin EPR-2. Send for copies today.

THE IMPERIAL BRASS MANUFACTURING CO.
Dept. PE-60, 6300 West Howard Street
Chicago 48, Illinois

KAUPP
PRECISION-FORMED
METAL
COMPONENTS

Hydroforming, Deep Drawing and Spinning

You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

C. B. KAUPP & SONS

Metal Craftsmen since 1924

NEWARK WAY, MAPLEWOOD, N. J.
Telephone: SOuth Orange 3-2490

READER TO EDITOR

What Engineering Shortage?

To the Editor:

At the risk of raising many eyebrows and creating considerable furore among the ranks of my fellow engineers, I would like to add a dissenting opinion to the rumors concerning an engineering shortage. I do not know where all this information is originating but I know for a fact that the words "engineering shortage" are nothing but a myth. While I acknowledge the fact that the New York *Times* carries four or five pages of engineer-job advertisements every Sunday, the requirements that are listed in fine print could not be filled by the great majority of the available engineering personnel since such personnel is nonexistent.

If you would care to check over the listings of available personnel with reputable agencies such as the Engineering Societies Employment Service, you will find that there are many capable and experienced engineers now looking for work. Furthermore, each month I see a large number of bulletins from various management consultants; these list page after page of available engineering personnel, a great many of whom are unemployed. I will also concede that there may be a shortage of basic-research scientists and teachers, but that is primarily because the prevailing salaries are so low. These very capable people look for employment in industry instead of remaining on the campus to engage in teaching and basic research, which will be so important to us if we aim to keep abreast with the rest of the world.

The many articles that have been published right and left by so-called authorities always stress that we are not producing enough engineers, and that many engineers are doing technician's work. I would be very much interested in at-

---

From P. J. Schott, Lee Engineering Div of Consolidation Coal Co, Columbus, Ohio, this delectable Transmission Menu:

Appetizers

Pickled Plug's Feet — Pickled Pinions
Hex Heads on the Half Shell (in season)
Hose Soup — Hub Cocktail

Entrees
(all served with hot 0. E. M. and butter)

Breast of Quill, under glass
Broiled Bearing Carrier served on sizzling Pressure Plate
Filet of Filter with Adapter Sauce
Roast Stuffed Pump
Toasted Trunnion with Disk Gravy
Hickory-smoked Stub Yoke
Valves, in sequence

Vegetables

Boiled Bearings — Sauteed Shafts
Mashed P.T.O. — Creamed Seals

Salads

Tossed Inputs and Outputs — Sliced Pinions
Springs & Spacers, chopped
Choice of Dressings: Thousand Washer
Assembly Cheese
Italian Lockwire

Desserts

Housing Pie, a la mode — Seal Sundae
Chocolate Gages

Beverages

Hot Hydraulic — Iced Schematic

Short Order:
Scrambled Clutches
Shaft Souffle
O-ring Omelet
Gear Goulash
Scalloped Cups & Cones
Pizza: Double Experimental & Piston
Gasket-in-a-Basket (with cap screws & packing)
French Fried Rings: Your choice of Piston, Snap, or "O"

Sandwiches:
Bushingburger
Grilled Shim
Cap Salad
Crushed Converter

tempting to find out what we will do with all these engineers if we were to obtain the large numbers that are supposed to be needed. It is well known that each year, while the population is increasing, the number of graduating medical doctors and dentists is decreasing and I cannot remember seeing any articles exhorting more people to enter these time-honored professions.

To justify a livable salary, many engineers are either leaving the profession, entering the ranks of management, getting involved in sales or becoming consultants. Since this is occurring at an alarming rate, could it be that all is not well and that the rosy picture painted by the recruiters is not all glory?

I, myself, am chief engineer of a prominent electromechanical-components manufacturer and over the last five years have never encountered any difficulties in obtaining qualified people. In fact, I can flatly state that for every position we have ever had to fill, we averaged at least five qualified applications from competent engineering personnel: *LET US ALL REMEMBER THAT WE ONLY GET WHAT WE PAY FOR.*

—George Merker
Fairlawn, NJ

COMING EVENTS

JUNE

5-10 . . . . Society of Automotive Engineers, Summer Meeting, Edgewater Beach Hotel, Chicago

13-15 . . . . Metal Powder Industries Federation and American Institute of Mining, Metallurgical & Petroleum Engineers, jointly sponsoring International Powder Metallurgy Conference, Hotel Biltmore, NYC

19-21 . . . . Alloy Casting Institute, Annual Meeting, The Homestead, Hot Springs, Va

20-24 . . . . American Society for Engineering Education, 68th Annual Convention, Purdue Univ, Lafayette, Ind

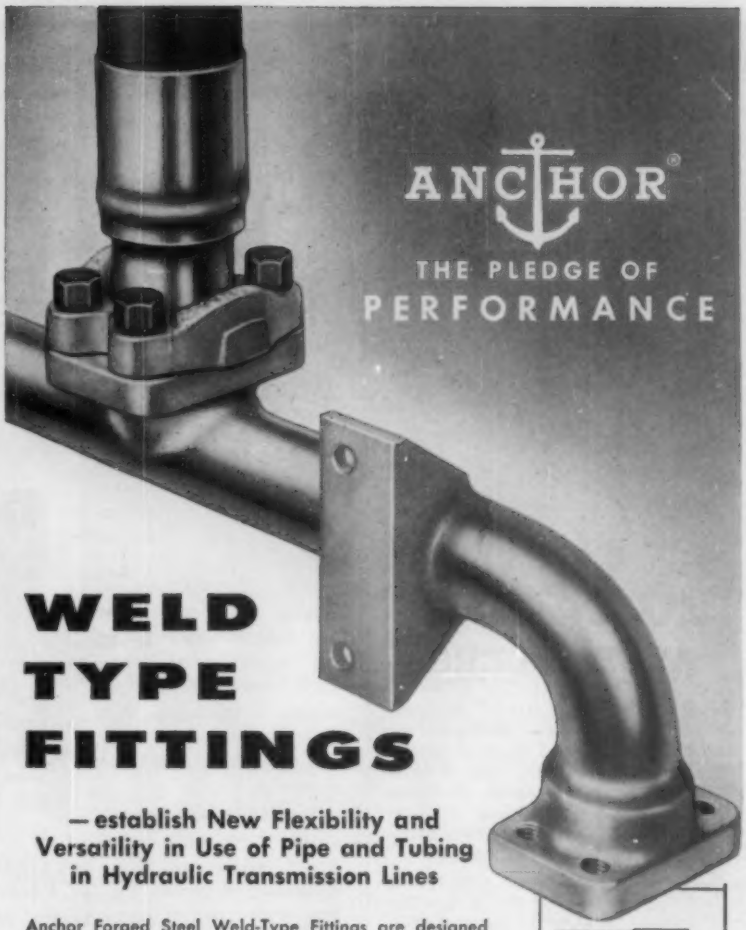
27-29 . . . . Institute of Radio Engineers, 4th National Convention on Military Electronics, Sheraton Park Hotel, Washington, DC

27-July 1 . . . . American Society for Testing Materials, 63rd Annual Meeting, Chalfonte-Haddon Hall Hotel, Atlantic City, NJ

AUGUST

1-3 . . . . Institute of Radio Engineers, 4th Global Communications Symposium, Statler-Hilton Hotel, Washington, DC

28-Sept 1 . . . . American Society of Mechanical Engineers, International Heat Transfer Conference, University of Colorado, Boulder, Colo



WELD TYPE FITTINGS

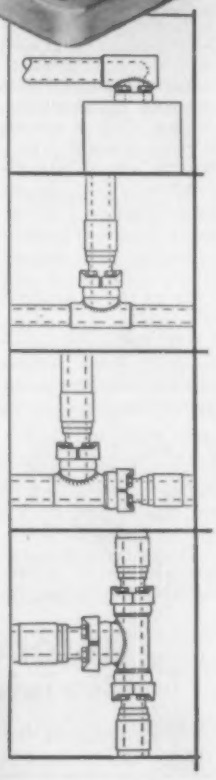
—establish New Flexibility and Versatility in Use of Pipe and Tubing in Hydraulic Transmission Lines

Anchor Forged Steel Weld-Type Fittings are designed especially for use with Anchor Split-Flange Clamp Halves and "O" Ring Flanged Head Couplings to create another Anchor Hydraulic "First."

They provide pipe and tubing assemblies with better flow characteristics. The need for pipe threads and pipe fittings, and their inherent problems, is eliminated.

Installation is extremely simple and dependable — Anchor Weld-Type Fittings are bolted securely to flange or port by four socket-head screws and an "O" Ring is employed to ensure a positive, leak-proof connection.

Anchor Weld-Type Fittings are available with drilled holes and "O" Ring Groove for bolting to valve or pump, or threaded holes without "O" Ring Groove for connection to Anchor Flanco Hose Assemblies by means of Anchor SAE 4-Bolt Split Flange Clamps. They are designed in straight, 90° elbow and tee styles for ends of pipe or tubing, and in saddle style for side positioning,—any number may be placed along the length of the assembly,—and in sizes for ¾" to 2½" pipe and for 1" to 2¾" tube.



Andy Anchor says:
"Don't delay writing for complete details and specifications.

ANCHOR COUPLING CO. INC.
336 North Fourth Street, Libertyville, Illinois
Branch Plants: Dallas, Tex., Plymouth, Mich.

● Build high strength rod, tube and pipe structures in minutes

● Save design and machining time on precision assemblies and fixtures with new

Rotocon
TRADEMARK
ASSEMBLERS

"Like genies from a lamp," says one pleased user of new **Rotocon** assemblers. Speed and ease of assembly, superior strength, and infinite adjustability recommend **Rotocon** assemblers for numberless applications IN LABORATORIES, INDUSTRY, INSTRUMENTATION, AUTOMATION.

Rotocon assemblers grip rods, tubes and pipes in a tight ALL-AROUND GRIP that never burrs, scores, or distorts. Toothed faces of paired units FORM RIGID JOINTS AT ANY 10-DEGREE INCREMENT, not just right angles. Only a screwdriver (or even a coin) is needed to tighten the fastening screw into the nesting nut.

With the exclusive SNAP-CLAMP unit, additions to structures or fixtures can be made without disassembling any parts. This snap-on clamp affords the same ALL-AROUND GRIP as other assemblers in the line.

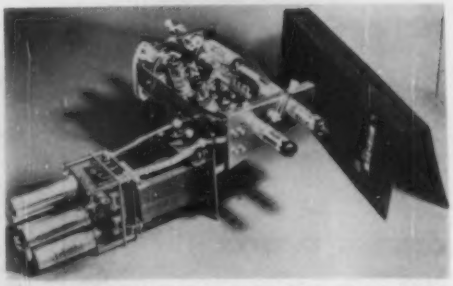
With so many uses in so many fields, **Rotocon** assemblers have to be seen, held in hand, and experimented with to reveal the time and money they can save you.

Sample Offer: A written request on your letterhead will bring you a sample kit of ***Rotocon*** *assemblers, free and postpaid.*

Rotocon Division
UNISTRUT PRODUCTS COMPANY
935 West Washington Blvd., Chicago 7, Ill.

FOR YOUR INFORMATION (personal)

High style for hi-fi



SWEDISH SPEAKER, ready to sound off, hides hi-fi power pack in high-styled case.

No, it's not a futuristic burner or an old-time cannon, but a Swedish hi-fi speaker. Designed by Count Sigvard Bernadotte, it's now being introduced in this country by Lund Industries – and there's more to it than the fancy exterior. Inside the acoustically designed enclosure is an integrated sound source with a matched speaker. Furthermore, two speakers can be joined to provide stereophonic listening with "no hole in the middle"–true spherical radiation of sound with "markedly increased technical efficiency, high acoustic power capacity, and low intermodulation distortion."

The amplifier-frequency curve of the unit is not, says Lund, basically flat. But the feedback network of the amplifier includes equalizing networks for the speaker system, designed to make the over-all frequency-response curve of the entire system, amplifier plus loudspeakers, basically flat.

Two separate amplifiers feed the loudspeakers, one working at 20 to 300 cps; the other from 300 up. Frequency response is attained chiefly by feedback. As the amplifiers have transformerless output stages, Lund claims an extremely large amount of feedback (about 55 db) can be applied.

Science made real easy

Do you know as much chemistry as a third-grader? Don't be too sure. If he, and his teacher, have had the benefit of a new manual prepared by the Manufacturing Chemists Assn, his erudition may surprise you. He'll know the difference between chemical and physical transformation, recognize that air is a real substance, and undertsand the combustion process. And, by the time he finishes the 6th grade, he'll be familiar with the basic principles of electroplating, crystallization, and photography–he may even have been introduced to the periodic table of elements.

Although the manual, *Matter, Energy, and Change*, was prepared for school use, it is just as helpful for exploring science at home with your own children; and copies can be obtained for 50¢ each by writing to MCA, 1825 Connecticut Ave NW, Washington 9, DC.

Everything on autos

Want the basic facts on antifreezes? Background data on auto seat belts? Information on antique automobiles? If so, the Government Printing Office has a booklet for you–really a dozen of them, as a matter of fact, priced from 10¢ to $1; plus a major text (573 pages), *Principles of Automotive Vehicles*, priced at $3.25. A new list of *Publications Relating to Automobiles* may be obtained from GPO, Washington, 25, DC. —ARG

SPECIAL NEWS REPORT ON

5th ANNUAL DESIGN SHOW & CONFERENCE

I–THE CONFERENCE: Keyed to the times, the Design Engineering Conference started with nuclear and missile experts reporting new products, predicting new techniques and power sources—and went on to discuss Reliability. Here are highlights of the morning sessions held at New York's Coliseum, May 23-27.

SPACE AGE SPURS DESIGN CHANGES

NEW YORK—Today's design horizons force engineers to cope with extremes of temperature, pressure and radiation. These, in turn, are forcing radical approaches to materials and component design—and promise to improve design efficiency of consumer and industrial products that have been on the market for a long time.

The possibilities of such cross-fertilization were assessed by a panel of nuclear and missile engineers at the opening session of the Design Engineering Conference here. Chairmen of the panel were Dr Hugh L. Dryden, deputy administrator of the National Aeronautics and Space Administration, and Dr Arthur R. Kantrowitz, director of Avco-Everett Research Labs, Avco Corp.

Nuclear technology has already scored an impressive array of new products, William R. Gall of the Reactor Experimental Engineering Div, Oak Ridge National Labs, told the session. These include submarines, central power stations and, most recently, rocket powerplants now under preliminary test.

Among techniques developed for reactors, which may have wider application, is the use of canned motor-pumps. In effect, these pumps have a "perfect seal" because motion is transmitted magnetically through a container wall.

Other nuclear applications

Special lubricants for the high-temperature environment of the reactor will also doubtless find wide application, Gall predicted. For higher temperatures, up to 1000 F, liquid-metal lubricants are now available; and for temperatures up to 1200 F, gas lubricants.

Also important to nuclear developments, Gall said, are mechanical manipulators. These master-slave mechanisms, which permit a person to remain outside a radioactive area, yet work in it, are now so intricately developed that remote-control welding of pipes is possible.

Among materials developed for reactors, Gall said, are alloys that resist corrosion in water at temperatures up to 650 F, and a molybdenum-nickel-chromium alloy that resists oxidation up to 1500 F. This alloy, known commercially as Hastelloy A and Inco 806, can be welded, work-hardened and retains stability at high temperatures.

It is no longer correct to think of nuclear reactors as uneconomical, Varick D. Schwartz of the Army Boiling Water Reactor Project at Combustion Engineering told the assembly. For some locations, such as the Arctic, where weather and long supply lines complicate supply problems, reactors are the best solution. These locations need a powerplant that is portable, reliable and easily installed; yet will operate over a wide range of temperatures, altitudes and ambient pressures. His firm, Schwartz said, has developed a unit that needs refueling only every 5 years, produces 1000 kw and operates from −100 to 60 F.

Missiles give byproducts

Arthur Shef, chief of space technology for the Institute of Defense Analysis (a private group advising the government on technical problems), predicted a variety of peacetime applications growing out of the missile

program. But he warned that in a few decades, his present list will doubtless seem trivial. At present, we can foresee missile applications to navigation, he said, assuming development of components that will reliably maintain frequency-stability for long periods. Another application is the repeater program for electronic communication beyond the horizon.

The satellite program, Shef continued, will depend heavily upon new materials. Structural materials of super strength, resistant to radiation and high temperatures, are essential. So are power-conversion materials for thermoelectricity and materials for electronic circuits operating at high temperatures. These improved materials will very likely have important side-applications in medical diagnostic equipment, he predicted.

A major accomplishment of the missile program, according to Elmer P. Wheaton, vice-president, engineering, Missile and Space Systems, Douglas Aircraft Co, is the emergence of systems engineering—the consideration of all aspects of a problem and how they feed into design.

These missile systems, Wheaton continued, are resulting in a "fallout of hardware." Frictionless bearings are one example. Douglas is applying the air bearing principle to its Glideair conveyor system for transporting passenger luggage at airports. Devices for auxiliary power supply are another design legacy. He predicted that fuel cells will have wide application ahead of portable nuclear power plants.

Dr Kantrowitz made the prediction that magnetohydrodynamics (MHD) will offer impressive possibilities for large power units producing 1 million kw or more. In large-size units, the efficiency of MHD approaches that of fuel cells. On the other hand, a unit producing 1000 kw is uneconomic.

FOCUS ON RELIABILITY

Fast-increasing importance of reliability engineering was shown by the large attendance and long question period at the session on Reliability. Among points of interest not included in our earlier special report (PE–May 16, p 65): Availability of Navy aircraft has been dropping 1% a year; maintenance on some missiles is 10 times the initial cost; cost per missile successfully fired in one program was three times the estimates. Among nonmilitary products, one appliance maker is calling back last year's output because of unreliability. Concentration on quality among foreign makers is resulting in high-reliability units competitive with American products.

Harry Powell of Space Technology Labs Inc, said reliability is now recognized as a physical phenomenon–a design parameter–while to the mathematician it is a probability. As the principle of concurrency gains favor because it shortens the new-product cycle by as much as half, time for testing becomes a luxury, so increasing dependence must be placed initially upon reliability calculations.

In discussion, Mr Powell pointed out that an inter-service program for exchange of test and trial data on components, now being set up, will save time and cut duplication of programs, permit terminology and test methods to be standardized. He explained current requirements for higher reliability in airframes than in guidance systems. More information is available on the former. Requirements on guidance systems will be increased as further reliability results are obtained.

EXPLOSIVE PROGRESS IN FABRICATION

Explosive forming, although still new, has fathered a number of processes, some already in production. Vasil Philipchuk, of American Potash, said material up to 3 in. thick is now being formed. Hardness of steel after forming can be controlled within acceptable limits, but weld quality must be high to prevent failure of the weld. Originally, explosive forming was used to stretch preforms, but now explosives are being used in the opposite direction: to compact powders, to reduce diameter of cylindrical forms, to weld. Still experimental, these techniques promise advances over their current counterparts. Steel welded by explosive charges, for instance, showed a very clear weld—no heat-affected zone. Welding of dissimilar materials is no special problem.

New materials bring new welding problems, said John Chyle, of A O Smith Corp. In turn, solutions found for these problems find use in less exotic applications, and older processes get refined. Magnetic force welding has been used successfully to 8 in. thick. Friction welding of metals, a Russian development, is finding its own field. Pressures from 1000 to 15,000 psi are being used.

For fiberglass-reinforced plastics, laminating techniques are still behind glass fiber development. William Dirkes, of WADC, reported parts of FRP must be fabricated under close control or their strength and reliability will go down. For example, in fatigue, reliable design strengths are about 30% of test values on FRP specimens. Practical elastic moduli are 50 and 60% lower than for parts made under carefully controlled conditions. Most of this discrepancy is from poor consistency in bonds between plastic and reinforcing fiber.

THE NEW LOOK AT PUMPS

Pumps on bulldozers and machine tools are becoming as cramped for space as those on airplanes, claims Edward I. Brown, director of engineering, Machinery Hydraulics Div of Vickers Inc. And the hydraulic fluids used are often overworked and abused.

Pressure of 4000 psi has been acknowledged the max practical for aircraft. At that value, over-all weight of the system (pumps, cylinders, valves, fittings, lines, tanks, accumulators) is at minimum for given power output. Most planes today have 3000-psi system pressure because components are readily available and weight saving at less-common 4000-psi level is negligible. Hydraulic press manufacturers have reached a similar conclusion: 4000 psi is optimum, but 3000 psi is handier.

Automotive power-steering applications require about 1200 psi (handled with vane pumps); off-the-road machinery, up to 2000; presses, 3000 to 5000. Metal-cutting machines are limited to range from 300 to 1000 psi because the larger flow volumes that result are easier to control.

Improved Hydraulic Fluids

Laboratory-test data do not always correlate with field-test data for hydraulic fluids–particularly the fire-resistant types–said Richard L. Leslie, supervisor, Fluids and Chemistry Group, of Vickers' R & D Dept. But a speaker, commenting on the paper, said recent tests show the standard 4-ball test correlates well with actual tests on Vickers vane pumps.

For radiation resistance, the polyphenyl ethers are best. Silicones provide the most suitable viscosity characteristics, but are only fair in lubricity. Petroleum oils have somewhat poorer viscosity, but are better lubricants.

Water is cheapest, and has low compressibility, low gas solubility. However it boils at low temperature, freezes easily and speeds up corrosion of some metals. Fluids with additives might break down due to shearing action in valves and pumps, reducing viscosity. Emulsification agents in some fluids will be filtered out–damaging the emulsion–if the wrong type filter is chosen. Metallic filters with relatively open pores are recommended.

Maximum temperature is limited by fluid pumped. In general, max temperature is 200 F for industrial, 250 F for mobile, and 400 F for aero applications. In the foreseeable future, allowable temperatures will rise–to 750 F for aircraft.

Design of a pump and its manufactured tolerances will influence performance. One gear-pump design has aluminum housing, and gears are allowed to "wear in" against the housing, assuring close clearances. Vane pumps are designed for easy disassembly, and the wearing parts can be replaced quickly.

Cost of pumps is a direct function of production. A 10,000-rpm, 1200-psi (peak) pumping package–including reservoir, filter and relief valve–can be bought for less than $10 in mass-production quantities. And it will last for years.

WHICH COMPUTER FOR WHAT?

In the control systems session W. E. Sollecito of GE said that an analog computer is an educated slide rule for handling differential equations. In discussion, he emphasized that the analog type is most effective in developing "ball park" answers in real time where parameters are not too well known. For preliminary answers, use a digital computer. Analog type is also helpful in analyzing nonlinear systems where mathematical theory is complex.

Discussion brought out need for a "library" of solutions to common problems such as the library currently available for digital computers. Most analog equipment today still uses tubes rather than transistors, primarily because of noise problems. Some complex problems today will require the combination of analog and digital systems to produce the desired answer.

In discussion following paper by A. S. Robinson of Bendix Corp, he explained that analog systems will remain superior to digital in problems combining high frequency response with only medium accuracy.

MODULAR MECHANIZED ASSEMBLY

"Modular design allows us to assemble with one machine all but a few of the 18,000 circuit boards in one Navy computer," said A. A. Lawson of Melpar Inc. Explaining how so much flexibility was gained, he said, "One way was by using interchangeable magazines. We load enough different components into these magazines to assemble any circuit.

"We standardized. Circuit boards are all the same size and shape. All components are handled by their leads. The machine doesn't care what the shape of the component body is."

FOR AUTOMATIC ASSEMBLY

"Keep sizes and shapes simple," was Rule 1 that Robert Esken of Sheffield Corp stressed. "Simple parts mean simpler assembly machines. Simpler machines mean less downtime. Complexity just invites trouble."

Concerning machine reliability, Esken pointed out, "Personnel can make a lot of difference. Quality of maintenance, how carefully the machines are tended, whether or not hoppers are kept full–these can affect downtime more than the machine's reliability."

COMPUTERS AT WORK

When computers are put to work on design problems, three questions must be answered: What kind of machine? How integrated in the engineering organization? How much will it cost? Most companies rent because today's computer may well be obsolete in two years. For example, a reentry problem that required 14 hr on an IBM 650 can be done in about 5 min on a 704. The next generation will boost this speed by another factor of 20 or 30. But these will be expensive: Over $125,000 per month for the basic machine and perhaps as much as $200,000 with all the extras.

II–THE SHOW:

WHAT PRODUCT ENGINEERING EDITORS FOUND

Visiting every booth at the Design Show, we examined what was on display and then talked shop with the exhibitors—to get even newer information. Here is our evaluation of new ideas and concepts, new components and materials.

MECHANICAL COMPONENTS

The manufacturers are offering improved ways to satisfy new needs. Here are latest developments and concepts in bearings, gears, springs, clutches, fasteners and lubrication.

More stocked springs . . .

. . . are available to the designer. Lee Spring Co, Brooklyn, is one more company beginning to stock compression and extension springs. Springs are made to Mil Specs QA-W-470 and QQ-W-423, and in sizes ranging from 0.057-in. OD to 0.850-in. OD. Spring rates go to 150 lb/in. Materials are music wire and stainless steel, and springs are stress relieved. Prices in quantities of 100: 7 to 40¢ each.

Magnetic toothed clutch . . .

. . . employs nylon teeth to avoid residual magnetism during release. The clutch, developed by Fawick Corp, Cleveland, can handle four times the torque capacity of a standard friction clutch, but must be engaged at low speeds. Toothed clutches are favored by machine-tool manufacturers for their high torque capacity and ability to be always engaged at the same point if need be–however, they tend to stick when released. The molded nylon teeth permit fast release even under full load.

The clutch is made in six sizes from 1½ to 7 in. dia and from 10 ft-lb to 1000 ft-lb torque capacity. They cost about 25% more than friction clutches but are cheaper per torque capacity.

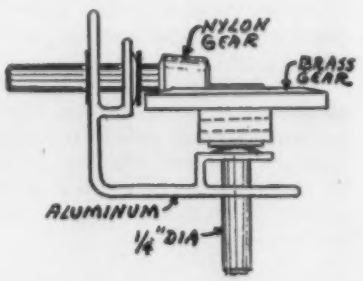
New backlash class for precision gears . . .

. . . was announced at the Show by Dynamic Gear of Amityville, NY. Designated "CD," the classification attempts to bridge the gap between Class C, which permits backlash of 0.0007 to 0.0015 in. (for gears with 60 to 120 pitch), and class D, which permit no measurable backlash. Backlash is measured between two assembled gears at their tightest point.

Class D is frankly considered absurd by many of the manufacturers, while Class C is too loose to satisfy demands of the precision instrument industry. Hence Dynamic's solution to create a CD class having a backlash range of 0.0002 to 0.0008 in. All precision gears (Prec I, II, III) made at Dynamic in the future will have a CD backlash unless otherwise requested.

Low-cost spiroid-gear assembly . . .

. . . providing a 19½ to 1 right-angle reduction for control mechanisms, is now available as an off-the-shelf item.



Developed by the Spiroid Division of Illinois Tool Works, Chicago, the device is for hand-driven, lightly loaded

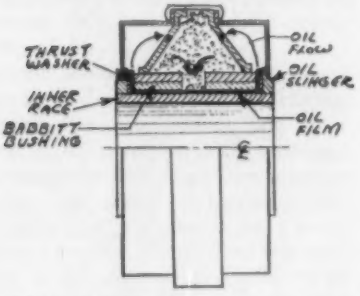
controls required for computer inputs, electronic controls, potentiometers and magnitron tubes.

The assembly consists of an aluminum-extruded L-frame, a nylon gear and cadmium-plated brass pinion, and spring washers to load the gears to avoid backlash. Other sizes and ratios are expected to be stocked soon.

New self-lubricated bearing . . .

. . . is first off-the-shelf bearing to support a shaft on a hydrodynamic oil film. The oil is drawn from a reservoir of self-wicking material, called Permawick, through bearing windows. Rotation of inner race under load generates a hydrodynamic oil film, supporting race without metal to metal contact. Oil is forced to ends by pressure and is recirculated by slingers that hurl the oil back into the wicking material, thus giving lifetime lubrication.

These "Hy-Film" bearings, produced by Tann Corp, Detroit, have a base life of 20,000 hr, are interchange-



able with ballbearings, are less prone to vibration and noise than ballbearings, and are reported leakproof. Recommended operating temperature: from −25 to 200 F.

Prices are comparable to medium grades of shielded ballbearings. The new bearings are headed for applications where noise, vibration and conducted resonance are a problem—as in appliances, electric motors, fans, pumps, grinders, mining and construction machinery.

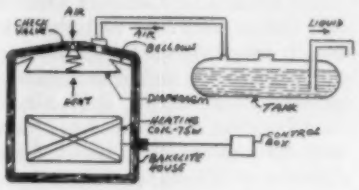
Oilite as an air bearing . . .

. . . needs no critical dimensions or orifices and is quite cheap to make. This pressurized type of bearing employs sintered powdered metal material rather than a drilled orifice concept. The material, produced by the Amplex Division of Chrysler, is the familiar Oilite material, but with the oil removed, and lubricated by pressured air. The material also can be furnished in long bars or plates to float the conveyance of a sensitive product such as film, thus avoiding abrasion.

In studies performed by the Chrysler Missile Div, relatively low pressures and flow rates were used successfully (under 120 psi and 15 ft³/min.) The bearings have been tested at speeds to 400,000 rpm, temperatures from −12 F to 1200 F, and have been built in various configurations. Amplex will sell the material in basic shapes or make the bearings to order.

Automatic dispensing system . . .

. . . for lubricating oils or corrosive liquids can now be metered and pumped by air without touching any

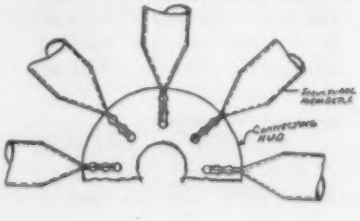


moving parts. Detroit Controls Div of American Radiator-Standard Sanitary Corp showed its air-expansion system with an ingenious pump which automatically dispenses precise amounts of liquids. The liquids—gummy and tacky by nature—never touch any moving parts, eliminating the possibilities of fouling or damage to the mechanism.

Though designed for home laundry equipment, the equipment needs only slight modifications to be applicable to any system where measured amounts of liquids are needed. With modifications of controls and piping, unit can be used to feed several outlets with one or more different liquids.

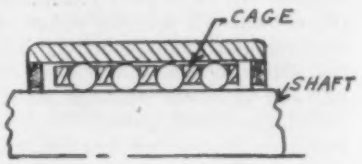
Fastening structural shapes . . .

. . . can be done without bolts, rivets or welds. F Fentiman & Sons Ltd, Ottawa, Canada showed its patented TRIODETIC structural system which uses a hub to connect several structural tubes (or any other type structural member). Hubs are produced directly by extrusion, casting or broaching; slots receive the ends of the tubes, which are prepared for connection by a pressing operation to fit snugly in the slots. Assembly is completed simply by slipping the member into the hub.



Reciprocating ballbearing . . .

. . . uses rows of caged balls to permit both rotational and linear motion without skidding. Manufactured by Orange Roller Bearing Co, pure roll-



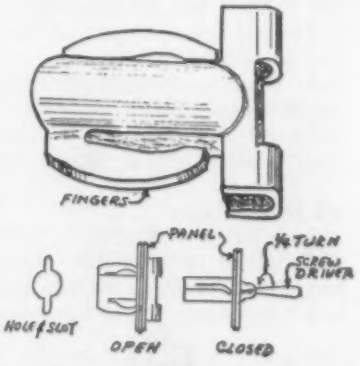
ing is obtained by making the cage shorter than the distance between end rings. Hence if cage is ¼ in. shorter, true stroke is ½ in.

Typical applications are for a lathe chuck head which moves linearly for alignment and then rotates; a stapling machine which vibrates and rotates; and a wire coiler to provide helical motion.

One-piece ¼-turn fastener . . .

. . . is inexpensive and simple. Produced by Tinnerman Products, Cleveland, the "Speed Clip" needs no separate stud and is for low-cost panel attachments where easy removability is a must. The fastener, completely reusable, is slotted to accept a standard screwdriver, can be turned with ordinary pliers—or by adding a wingnut.

In operation, the spring legs of



Speed Clip twist into retaining position with a ¼-clockwise turn. The legs bite hard in the panel to prevent backoff or vibration loosening. Removal is simply a matter of another ¼-turn; the legs snap free into the mounting hole. Typical uses are for panels, access covers, doors, electronic-chassis mounting and expendable shipping.

—Nicholas Chironis and Fred Marich

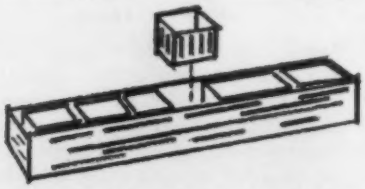
ELECTRICAL POWER AND CONTROL

One highlight at the show was a compact variable-speed drive—all-transistorized. Most of the new electrical products shown were examples of good, practical design rather than of the "breakthrough" type.

Variable-speed control . . .
. . . made by American Car and Foundry (ACF) Electronics Div, Paramus, NJ, for dc shunt motors, has silicon controlled rectifiers instead of thyratrons for electronic power control. Novel feedback circuit based on back-emf of motor windings adjusts ACF trigger circuit (patented) to controlled rectifiers so fast that full load can be applied at any speed from about ⅛ to full speed without appreciably slowing down motor. Lack of conventional vacuum tubes overcomes several obstacles: heat loss; bulk; time delay in shutting off power signal during each ac cycle. Control will be available from 1/6 hp up to 10 hp. Can be single or polyphase, 50-60 cps, 120-220 v (higher voltage requires step-down transformer), and can be supplied with dynamic braking, reversing and jogging controls. Speed regulation is nominally 1% for full 8:1 speed range, but can be improved by adjustment for any given smaller range. Higher than 8:1 speed ratios are also possible. Dimensions of typical control: 11 x 12 x 7 in. Weight is 19 lb enclosed, 8 lb open.

Motor-reverse switch . . .
. . . made by Franklin Electric Co Inc, Bluffton, Ind, for its garage-door motors and similar types, uses backlash in worm gearing to sense overload. When mechanical load exceeds predetermined value, the natural movement of gear relative to pinion operates microswitch, reversing motor.

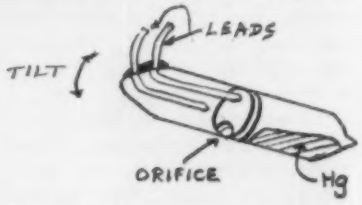
3-D printed circuits . . .
. . . are feature of electronic module shells offered by AMP Inc, Harrisburg, Penna. Shells are made in sizes to suit application, and contain spring



contacts and interconnecting circuitry matched to your components. Each cell is friction-fitted into the 3-D circuit-board enclosure, and makes all necessary contract without soldering or bonding. And by making side walls higher, more cells can be stacked one over the other. Customer's components are preassembled, wired and dropped into the cell (called AMPLUG), and can be attached to cell contact tabs by welding or soldering. Parts can then be encapsulated.

Smallest coil winding . . .
. . . is claimed by Miniature Product Div, Deluxe Coils Inc, Wabash, Indiana. It was designed for special government project, and is not offered for sale. Wire size is #56 AWG, 0.0005-in. dia. The 250 total turns were first wound on mandrel, then slipped over 0.01-in. sapphire rod for use in sensing instrument.

Mercury time-delay switch . . .
. . . introduced by Gordos Corp, Bloomfield, NJ, has special orifice plate that slows movement of mercury



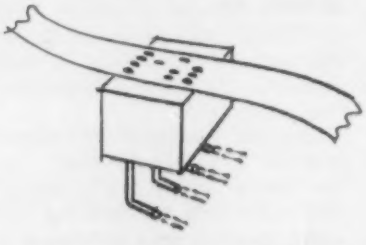
when switch tilts. Delays can be from a fraction of a second to minutes, depending on the amount of mercury sealed into glass capsule. Available model (sketched above) has several-second delay in opening direction, but closes without time delay because bottom terminal is located near orifice in divider disk.

Miniature electric clutch . . .
. . . only 1 in. dia with a torque rating of 1.5 lb-in. has been added to the line of fractional-hp clutches by Warner Electric Brake & Clutch Co, Beloit, Wis. Axial length is only ⅞ in. The same construction is also supplied as a brake; standard windings are available for 24 and 100 volts dc.

30-speed transmission . . .
. . . is addition to Autotronics line of multiple-speed miniature power drives. With 5000 rpm input, output speeds range from 4000 to 0.4 rpm in geometric progression. Device is 3¾ x 4 x 7 in. long; output torque is 55 oz-in. min.

Miniaturized cycling timer . . .
. . . just announced by the R. W. Cramer Co, combines 5 circuits, each individually adjusted for time interval. Housed in a sealed enclosure 1 x 2 and 3 in. long with plug-in electrical connections. Timing motors available for 60 cycle dc and 400 cycle ac. Contacts for each circuit will double pull with a reading of 10 amp ac and 5 amp dc.

Music-roll numerical control . . .
. . . interprets punched tape pneumatically to position table in Moore Jig Borer. Control—made by Sperry Gyroscope Co of Canada Ltd, Numerical Control Div, Montreal, Quebec—is designed for point-to-point positioning and is not intended for contour machining. Over-all system cost is relatively low. Pneumatic reader releases air pressure when hole in block is opposite hole in tape. Simple microswitch, actuated by air diaphragm, transmits signal. Hydraulic cylinders operate machine's table in both directions, and positioning is with linear transducers (Farrand linear-selsyn type in model exhibited). Positioning accuracy is assured by letting table overshoot a mil or so, then oscillating it back and forth rapidly, reducing error to ± 0.0005 in. over-all, 0.0001 in.



repeatability. Sperry supplied special rotary electrohydraulic servovalve for the job, but would not disclose its design, claiming it was secret to success of servosystem.

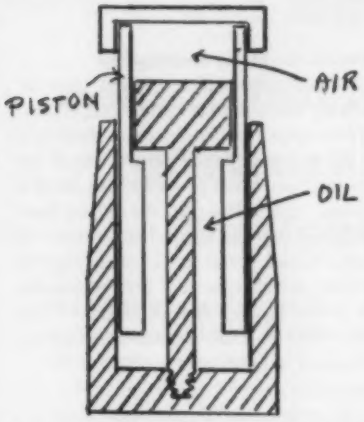
Molded rubber plugs . . .
. . . on cord sets developed by Miller Electric Co, Pawtucket, RI, are now available with 2-prong and 4-prong plugs that fit standard Jones receptacles. Plugs are fitted with a polarizing pin. Also shown was standard male plug with finger-hole for easy removal.—**Frank Yeaple, R W Carson**

FLUID POWER AND CONTROL

A liquid spring designed for 1 million lb. force accentuated the trend to higher pressures in hydraulic systems. Machine controls, cylinders and tubing manufacturers led in new ideas. Here are a few:

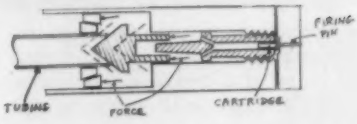
Million-lb liquid spring . . .

. . . intrigued engineers at show. Purpose was to encourage questions, help remove misconceptions about liquid springs, and explain how they work. Sketch below shows that only thin outer wall of load piston actually compresses the silicone liquid used; reduces volume less than 10% from zero to 20,000 psi. Operating data: 1.25-in. travel from 5000 psi (250,000-lb load) to 20,000 psi (1,000,000-lb load). See PRODUCT ENGINEERING article "Liquid Springs," Aug 17 '59, p 54.



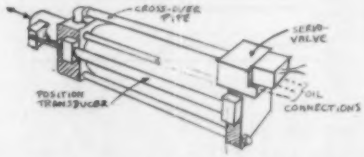
Explosive flaring tool . . .

. . . for heavy-walled stainless-steel tubing, will flare ¼ to 1¼-in.-dia tubing, with up to 0.120-in. wall. A second tool is planned for diameters to 2 in. Marketing plans were not disclosed by Parker Fittings and Hose Div, Parker-Hannifin Corp, which introduced it, but sketch illustrates simple principle. Cartridge is standard crimped-end type, but must have proper charge to avoid danger.



Building-block servo . . .

. . . that assembles on standard square-head cylinder and sells for less than $1000 complete with cylinder (shown in sketch below), is now offered by Vickers Inc, Machinery Hydraulics Div, Detroit 32, Mich. Not shown are the electronic controls (power supply, programer, amplifier); cost for these is less than $500 additional. Relatively low cost results from simplicity. There is no speed control on cylinder movement—a simple flow-control valve sets max fluid flow; and position is measured with linear potentiometer, giving accuracy of about 0.001 in. Another building-block package will be offered soon: a servo-controlled motor instead of a cylinder, with 250:1 gear-ratio reducer on 5-in.-dia feedback potentiometer for positioning. —Frank Yeaple



MATERIALS AND PRODUCTION PROCESSES

Along with new finishing processes for decorative appearance, materials for extreme service environments were also introduced.

High-temperature aluminum impacts . . .

. . . start with metal-powder slug. Instead of sintering to finished form, the aluminum - powder - metallurgy (APM) material is impact-extruded to finished shape. One prototype part—a ½-in.-dia finned tube, with length up to 14 ft—has wall-thickness tolerance of 0.003 in. Strengthened by dispersing fine particles such as aluminum oxide has been known to increase creep strength up to 20 times when temperature is above 90% of melting point. Process is adaptable to any impact-extruding shape.

Rubber-on-phenolic laminates . . .

. . . for special applications which require resilience, shock absorption or sealing, were announced by National Vulcanized Fibre of Wilmington, Del. Rubber can be supplied bonded to one or both sides of the laminate, or sandwiched between two sheets. Rubber grades available are: Buna S (for gaskets); Buna N and Neoprene. Thickness of rubber layer ranges from $\frac{1}{64}$ to $\frac{1}{8}$ in.

Formed-in-place ceramics . . .

. . . need no separate firing. Two ceramic powders developed by Corning Glass can be cast or pressed into shape and bonded in use. Both have good dimensional stability. "Corcast," the casting form, does not shrink in drying or firing. Its thermal coefficient of expansion is negligible. It is usable up to 2500 F. "Cortamp," the compacting form, when initially pressed together, is held by an organic bond. Heating to 1300 F changes adhesion to a chemical bond and at 2700 F to a ceramic bond. Service temperature of this version is above 4000 F. Expansion coefficient is about 3×10^{-6} in. per in. per °F. A 0.3% shrinkage occurs at 2700 F when the bond changes to ceramic.

Water-soluble lacquers . . .

. . . when baked on, can be more protective than other baked coatings, such as modified alkyds and thermosetting resins. Clear, transparent lacquer introduced by Bee Chemical is claimed to be able to withstand at least twice the salt-spray exposure as other water-soluble lacquers without coating failure at sharp edges or discoloration.

Lead-Teflon lubricant . . .

. . . a mixed powder, is impregnated into bronze metal-powder bearings to lower friction and wear. English development, shown by the Lead Industries Association, uses Teflon for low coefficient of friction and lead to conduct heat away from the film to the porous bronze liner.

Photosensitive glass . . .

. . . formerly a novelty, is finding commercial applications. Corning Glass displayed first application—an aircraft-instrument dial. Exposure to light turns the clear photosensitive glass into a cloudy form that is easily etched away by hydrofluoric acid. Sheets of the glass can be readily made into complex circuit boards for high-temperature components. Three grades are available in both the glass and

ceramic forms. July 4th issue of PRODUCT ENGINEERING will present the first design data.

New nylon-fiber glass premix . . .
. . . contains up to 40% short glass fibers. Formerly limited to 18% glass fiber, new injection-molding material has increased strength from higher glass content. Strength, however, does not go up linearly with percentage of glass fibers. Also, high fiber content is more difficult to mold without having some errant fiber breaking through to surface. Produced by Fiberfil Inc of Warsaw, Ind.

Metallic particles . . .
. . . in a liquid acrylic-resin carrier give a new spray-on finish. No special spraying equipment needed. Excellent dispersion of metallic particles (from aluminum foil) gives a uniform appearance. A second coat of acrylic sandwiches the metal particles and gives a smooth finish. Tinting of the second coat makes possible a wide range of tonal variations. A Dobeckmun Co development, this finish can be used on all surfaces, including leather, paper, fiber.

Electroplates for aluminum . . .
. . . low-cost process promises large-volume applications. New platings of nickel and copper, which have good adherence, can be used as base for chrome plate. The process, developed in Canada, was shown at the Canadian Dept of Trade & Commerce booth. It is reported to have been licensed to a major US auto manufacturer.

Forgings . . .
. . . are being tried with an explosive charge providing the power. Advantage is that power can be supplied at the required level by simply changing the amount of explosive.

Also new is a process to provide hemispherical and dished shapes by progressively forcing sheet steel into the shape of a female die. Force is applied through small rollers on the concave side.

Pearlescent finishes . . .
. . . with a lead carbonate base are now available for application over paint, lacquer, shellac. Lead Industries Ass'n points out that the finish is subdued, a change from the usual mother-of-pearl look.

Continuous castings . . .
. . . can be made of any alloy containing at least 60% Cu, with other constituents in a variety of maximal percentages, according to Asarco. New is the increase in phosphor content (up to 9% P) of phosphor bronze to solve special bearing problems.

Die-forms . . .
. . . by Republic Steel are the answer to multidiameter shafts. It is the latest in the trend to moving–rather

than removing–metal. Savings of about ⅓ in steel alone are claimed. There are additional savings in machining and in the strength of the shaft.–**Herbert Kee, Felix Giordano**

ENGINEERING DEPARTMENT EQUIPMENT

Tools that help the engineer do a better job are becoming more specialized, more accurate.

Precision layouts . . .
. . . of templets and grid structures is provided by a machine called a Coordinator-graph marketed by Unitech Corp, Clifton, NJ. It scribes out a drawing by cutting away the opaque coating on a glass plate or plastic-base material with a sharp stylus. Looking like a tamed-down version of a ruling engine, the machine will cut straight lines by means of precisely calibrated X - Y stylus motion and will scribe out concentric circles with rotation of a combined lightbox-turntable holding the drafting medium. Unitech imports the machine from Germany and sells it here for a price in the $5000-6000 bracket. Chief application at present is for layout of templets for optical comparators.

Drafting furniture . . .
. . . remains essentially unchanged, with no important innovations evident this year. Hamilton Manufacturing Co, Two Rivers, Wis, was showing their new canted leg table, a handsome and sturdy-looking affair but without Autoshift feature that permits easy adjustment of board height and angle. This one, like their modular unit of a year ago, is intended to blend with executive-styled decor but, with its thumb-screw-and-rod for angle adjustment, is evidently designed more with an eye to beauty than utility. A German-built drafting machine and board is now being distributed by United Corp, Clifton, NJ. The drafting machine has a counterbalanced (with troublesome overhanging weight) parallelogram linkage which, it is claimed, reaches more board area than other arm-type machines. The board is also counterbalanced, moves up or down at the touch of a pedal and tilts.

Pencils for Mylar drafting film . . .
. . . were shown for the first time by Dixon Sintolloy Inc, Stamford, Conn. These appear to be the equivalent of a 9 H drawing pencil when tested on an ordinary sheet of paper, but leave a sharp, dense line on the Mylar-base films so popular in drafting rooms of late. Chief advantages, according to Dixon, are sharpness of line, resistance to smearing and ease of erasure. The No. 7000 F. T. R. pencils come in six standard weights.

Catalogs on microfilm . . .
. . . one answer to the problem of hefty, easily pilfered, volumes scattered hither and thither around the design department. A new service known as VSFM and offered by Technical Services Div of Rogers Publishing Co, makes the catalog pages of a large number of manufacturers available at the flip of a switch. A particular document can be selected by scanning the appropriate roll of microfilm on the screen of a motorized viewer. The engineer is guided to the proper roll by identifying tags and a book listing cross-referenced headings. A permanent copy of screen image can be made in 14 sec by depressing a photocopy lever at top of viewer. The service is leased to users for an annual fee of about $3000-4000 per viewing station. Fee includes viewer, microfilm rolls, service and updating program.

Torque indicator . . .
. . . for measuring light torque–0.05 to 1.5 oz-in.–has been added to the line of center-zero instruments made by Autotronics Inc, Floussant, Mo. Load sensing system is a set of three parallel thin beams cut from a solid, hollow shaft. **–C J Lynch**

CIRCLE 25 ON READER SERVICE CARD→

working with

Du Pont Zytel®

nylon resins

one of Du Pont's versatile engineering materials

Revolutionary advance in rifle making . . .

Remington Nylon 66 of structural Du Pont ZYTEL®

Remington's history-making design uses Du Pont ZYTEL nylon resin—here's the first rifle ever to be made with a structural-nylon stock!

ZYTEL is one of the toughest, most durable organic materials known. The stock is chip-proof, waterproof, oilproof. ZYTEL nylon is light in weight, too . . . the new gunstocks have 1/5 the weight of wooden stocks with no loss in ruggedness. Even when soaked in water, these stocks will not warp. There's no need for lubrication. ZYTEL permits complete integration of stock, receiver and barrel . . . allows tolerances that deliver the most trouble-free autoloading 22 action ever known. The stability of ZYTEL makes it possible to use three-point micro-bedding of the barrel for match-rifle accuracy at moderate cost. ZYTEL is heat-resistant. Hours of steady firing have no effect on the stock. The moldability of ZYTEL insures perfect 16-to-the-inch checkering. The colorability of ZYTEL ushers in a new era in stock design. The new Nylon 66 comes in two distinctive colors, Seneca green and Mohawk brown.

The strength, durability, abrasion resistance, low-friction properties of ZYTEL offer you many possibilities when you design a new product or component, or wish to simplify and update an existing product. On the following page are more examples to suggest profitable design improvements for *your* products.

NEW REMINGTON 22 is the first rifle with a structural-nylon stock. Made of Du Pont ZYTEL nylon resin, the stock is light in weight and durable under all field conditions. (Nylon 66 autoloading 22 rifle manufactured by Remington Arms Company, Inc., Bridgeport 2, Connecticut.)

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING

. . . THROUGH CHEMISTRY

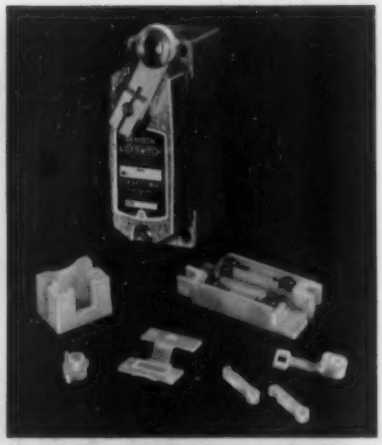
working with

Du Pont Zytel®

nylon resins

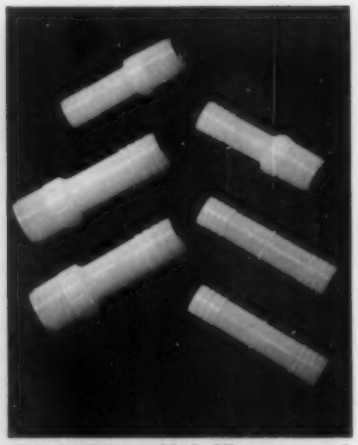
one of Du Pont's versatile engineering materials

Outstanding properties of ZYTEL® vital to many improved designs



ELECTRICAL LIMIT SWITCH made with 7 parts of ZYTEL lasts at least 5 times as long as former switches made with metal or other plastic components. The low friction and wear of ZYTEL enabled parts to hold to required dimensions after 65,000,000 test cycles, and the high arc resistance of ZYTEL prevents arc tracking. (Limit switch is molded by Berea Plastics Co., Berea, Ohio, for R. B. Denison Mfg. Co., Bedford, Ohio.)

COUNTER for instruments such as clocks and high-speed money counter uses drums, gears and other components molded of ZYTEL. Reasons: ZYTEL can be molded to close tolerances, and it offers the abrasion resistance and high fatigue endurance required for long, trouble-free service. (Molded by B & B Plastics, Inc., Oakville, Connecticut, for Haydon Instrument Company, Waterbury, Connecticut.)



PIPE FITTINGS molded of ZYTEL are used to connect plastic pipe with plastic or metal pipe. Pressure grooving and threads are molded into complex hollow shapes. Toughness and resistance to corrosion are typical of the properties you get with ZYTEL. (By Nylon Molded Products Corp., Garrettsville, Ohio.)

In addition to excellent electrical properties and resistance to corrosion, the mechanical properties of ZYTEL nylon resins usually give longer wear, even when subject to abrasion, impact or temperature extremes.

Du Pont ZYTEL may well help you save money by reducing production costs and giving improved performance under adverse conditions. Find out how by filling out and sending in the coupon below.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.), Dept. A: 1 2 3 4
Room 2507Z, Nemours Building, Wilmington 98, Delaware.
I am interested in evaluating ZYTEL for the following use:

_____

*Name*_____

*Company*_____ *Position*_____

*Street*_____

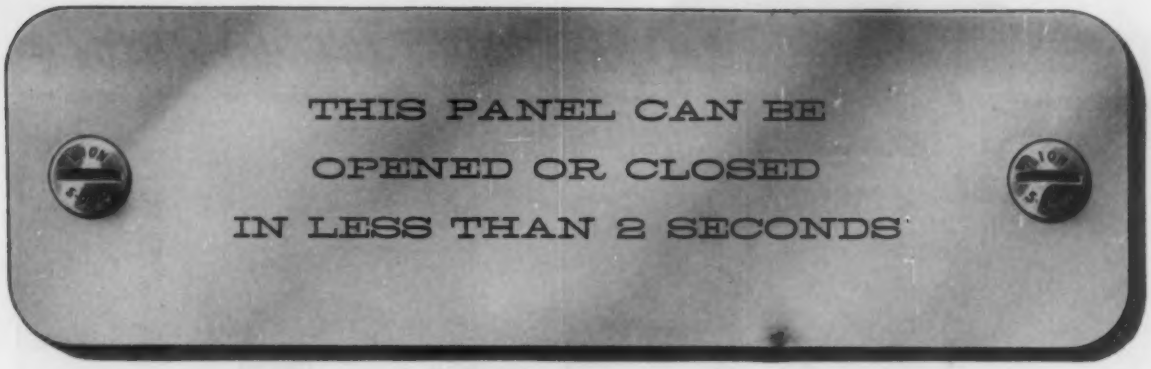
*City*_____ *Zone*____ *State*_____

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

ZYTEL® *nylon resins*

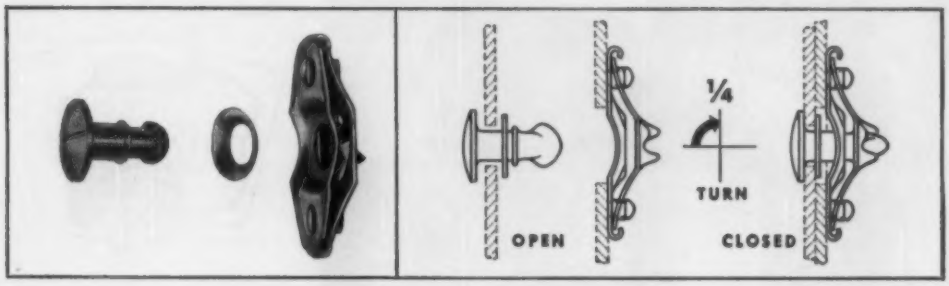
one of Du Pont's versatile engineering materials

Alathon® · Delrin® · Lucite®



LION ¼ TURN OPEN ¼ TURN CLOSED FASTENERS

ARE FAST, POSITIVE, RELIABLE



Installation of the three parts of the Lion Fastener, shown above, is quick but not critical. Unique in design and performance, these mil spec (MIL-F 5591A-ASG) fasteners make possible quick access and smooth positive locking by only a ¼ turn.

ALIGNMENT NOT CRITICAL

Both stud and receptacle "float" to accommodate misalignment. The hole, which retains the stud, is twice as large as the stud cross-section. This permits a float of .070 in all directions. The leaf spring receptacle also floats to accommodate stud position.

WIDE VARIATIONS IN STACK HEIGHT

Total sheet thickness may vary as much as +.035 and −.015 without affecting operation. A Lion stud, specified for .160 total thickness, for example, will accommodate any stack height between .195 and .145.

SWAGED-NOSE STUD

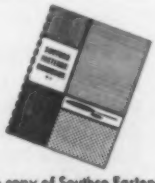
Extra strength and smooth operation are made possible by the swaged-nose design. All the metal in the stud goes to work. There are no thin cross pins, holes or milled slots to weaken the cross-section. Case hardening is further assurance of long, trouble-free service.

WIDE VARIETY

Lion Fasteners are available in 3 sizes—No. 5, No. 2, and Miniature. An assortment of head styles are supplied—oval, flush, wing, ring, notched or knurled—according to individual requirements.

FREE!

FASTENER HANDBOOK



Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and other special fasteners. Write to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pennsylvania.

©1959

LION *Aviation* FASTENERS

one of the

SOUTHCO LION FASTENERS

PRODUCT INFORMATION

N/D sound booth for analysis of electric motor noise, mounted on springs and constructed with non-parallel walls, assures manufacturers a *scientific solution* to electric motor noise problems. Motors are tested with special electronic sound evaluation equipment.

How N/D Minimizes Electric Motor Noise!

In New Departure's full-time noise analysis program, a unique sound booth and special electronic sound level equipment are used to pinpoint and evaluate electric motor noise. Inside the booth, a condenser microphone picks up air-borne noise from the running motor. Outside, the signal is electronically registered and recorded.

By changing one variable at a time, such as bearing or mounting design, or lubricant, N/D engineers are able to select the proper combination that results in the quietest motor operation. That's why you'll find New Departure precision ball bearings specified for electric motors to be used in quality home appliances, instruments, fans, hand tools and other applications . . . for greater consumer sales appeal.

If you have an electric motor noise problem, contact the N/D Sales Engineer in your area. For additional information call or write New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE

BALL BEARINGS

proved reliability you can build around

PRODUCT ENGINEERING HORIZONS

June 6, 1960

ONWARD TO MEDIOCRITY?

Many a woman without the necessary genes now sports red or auburn hair; the ranks of the overly blonde have thinned. Waist and hem lines are in such perpetual motion that economists have tied them to the business cycle—or vice versa.

These are fashions, fads, the vagaries of the opposite sex. But few of us who thus lightly dismiss them recognize similar fashions in even our most serious enterprises. We've passed from the era of the tough boss to the understanding one and are swinging back to toughness again. We're beginning to wonder whether the ideal executive, who is described as having such contrasting attributes as "gets along well with people" and "has integrity and strength of character," or "decisive" and "conservative," wouldn't be a spineless jellyfish if he actually existed.

Or consider the corporations which, a few years back, had to have salesmen as presidents. Then it was the banker, the lawyer, the general; now it is increasingly the controller. Policies and attitudes change with these changes in top background. We now have executive structures spotted with former bank tellers and graduates of "B" schools. Business is based on the balance sheet and the budget. Caution is the order of the day, conservatism the ultimate. Risk is a horrid word.

This is, of course, none of our business; "ours not to reason why," as Tennyson put it. Except as it affects engineering. And that's what it does. Because, in the face of this balance-sheet economy, engineering is supposed to take giant strides, to push the company and the country into the lead.

Perhaps we need to resurrect Merlin or some other wizard, who created miracles with nothing up his sleeve. Perhaps some seer can tell us how engineering can move aggressively ahead when management policy is to hang doggedly back.

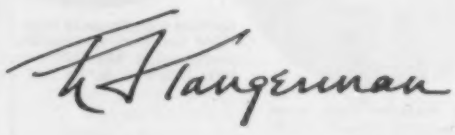
There was a time when budgets were a guide rather than a god, when executives were chosen for their willingness to take risks and fight them through. Apparently, our companies are now growing so big, and ownership is so largely in estates, trusts and widows' rather-considerable mites, that conservatism is the order of the day. Don't over-extend, play it safe, don't upset the applecart, stay within the thrice-pared budget.

Even engineering: "Redesign the whole line—but don't make any changes that will get us in trouble, or raise our costs, or require new investment. Better still, develop a whole new line; somebody just said that business ten years from now will be based on products not yet invented, so let's get in on it—conservatively, of course. We can't put a lot into R & D—that sometimes doesn't pay off, so you'll just have to make do."

Except in missiles and space. There Uncle Sam will foot the bill, so even the sky isn't the limit. There the further you cut loose, the better.

And where do the breakthroughs come? In missiles and space work, where the inhibitions are off, where engineers can still make real forward strides. There the controller is stymied, at least temporarily, because the customer asks for, and insists upon, the big leap on every model. Sure, it costs money, but the customer is concerned about tomorrow—and an aggressive competitor who at the moment, at least, is a leap ahead.

The moral is simple: If you want a man to look out of the window and see the stars, don't pull the shade.



Reusable and Swaged-On Assemblies!

COMPLETE LINE OF SURGEPRUF COUPLINGS AND HYDRAULIC HOSE

Only Surgepruf Reusable Couplings and Hose Have These Outstanding Features:

Superior Fluid Seal eliminates seepage between coupling shell and wire braid • Non-Skive Assembly provides fastest field assembly with just ordinary tools • Superior Finish—precision-machined steel couplings have zinc dichromate finish to pass rigid salt-spray tests • Full Interchangeability—regardless of hose line, Surgepruf couplings are available in any style and thread.

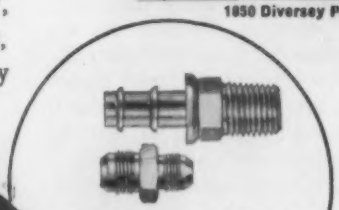
Now from one reliable source... a full range of Swaged-on Assemblies and Shurlock Reusable Couplings, Hydraulic Hose... and Adapters!

Get superior performance . . . dependable operation with the expanded Surgepruf line. From low pressure to high pressure hydraulic applications, Surgepruf new design and quality features provide the rugged and dependable service you *need* for *all* equipment . . . plus fast, easy on-the-job replacements!

Contact your Wholesale Supplier—or write for the following Surgepruf catalogs: No. 40-25, Reusable Coupling and Hose Catalog; No. 40-27, Swaged-on Hose Assemblies Catalog; No. 40-36, Adapters Catalog. Dept. 524, 1850 Diversey Parkway, Chicago 14, Illinois.

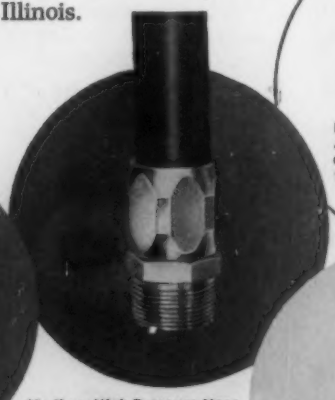
Symbol of SW Excellence

ALEMITE DIVISION
STEWART-WARNER CORPORATION
1850 Diversey Parkway, Chicago 14, Illinois



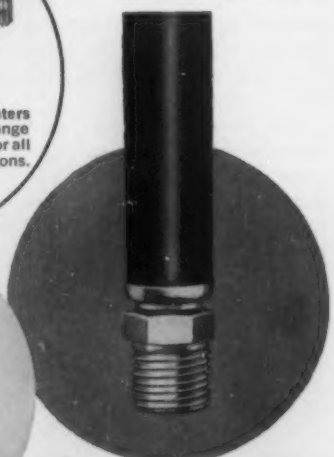
Reusable Couplings & Adapters Available in a complete range of thread styles and sizes for all types of machine connections.

High Pressure Hose. Burst and working pressure equivalent to SAE 100R2. In hose ID's from ¼" to 2".



Medium High Pressure Hose. Burst and working pressure equivalent to SAE 100R1. In hose ID's from 3/16" to 1 13/16".

Medium Pressure Hose. Complies with SAE 100R3 requirements. In hose ID's from ¼" to 1".



Low Pressure Hose. Burst pressure, 1000 psi.; working pressure, 250 psi. In hose ID's from ¼" to ¾".

HOW TO SPECIFY FINISHES FOR MAGNESIUM

A selection guide to the most suitable finish system, including chemical treatments and organic coatings for best properties at lowest cost.

JOHN A STEVENS
Finishing specialist, Dow Metal Products Co

The type of finish for magnesium depends upon the field of application. Military needs cover a wide range of extremely severe corrosive conditions, so complete protection has always been emphasized. However, commercial products allow some leeway. In many atmospheres to which magnesium and its alloys are subjected, even the bare metal builds up a thin gray protective film. But this is not always sufficient. For a decorative appearance or for resistance to severe environments, some type of finish is generally specified.

When the environments call for a protective finish, selecting the proper type is a four-step process:

1. Establish physical, chemical and decorative needs.
2. Appraise the metal in terms of its corrosion-resistance and paint-adhesion properties.
3. Compare the specifications for the various coating methods available, to see which best fulfils the application requirements.
4. Choose the best finish system—guided by Step 3 and by finishes used successfully in similar applications.

ADHESION OF ORGANIC PAINTS

Adhesion of paint is a combination of three mechanisms: chemical attraction, chemical interaction, and mechanical adhesion. In general, adhesion is destroyed by alkali (the degree depending on alkali resistance of the vehicle) and by heavy surface films on the metal. Because bare metal surfaces are alkaline to varying degrees, surface treatments, usually chromate or phosphate, are used to give films which are thin or porous, and slightly acid to neutral, to obtain consistently good adhesion.

Most paints will adhere well to magnesium except when a scratch penetrates to the bare metal. Inasmuch as the corrosion product at the scratch is highly alkaline (pH about 10.5), it will destroy adhesion of the paint and undercut the scratch unless the vehicle is alkali resistant.

THE BASE METAL

Clean, bare magnesium is not attacked by chromic or even hydrofluoric acid and is inert to alkaline solutions. With chromates, fluorides, vanadates and phosphates, it gives an insoluble film that suppresses further attack. The formation of such films is the basis for chemical treatments that inhibit corrosion or promote paint adhesion.

Magnesium metal is not attacked by organic solvents and therefore does not need any special organic finish practices or equipment. The metal is attacked by dilute mineral acids and low-molecular-weight organic acids. Some high-molecular-weight organic acids will stain bare magnesium and magnesium alloys.

When exposed to air, magnesium (usually in the alloy form—for structural strength) forms a self-protective film of basic magnesium carbonate plus oxides of the alloying elements. The film is alkaline and, if kept dry, it remains thin and translucent. In moist conditions, it grows thicker and darker, with rate of formation governed by alloy composition and severity of exposure. Certain ions, especially of chloride and heavy metals (copper, iron and nickel) materially increase rate of film-formation.

Unlike the dense protective films on aluminum, which form rapidly and then level off, the magnesium film continues thickening—because, being less dense than the base metal, it can buckle or crack, exposing still more base metal. Continuously wet conditions are necessary for such growth.

SURFACE FILMS AND TREATMENTS

As a paint base, the alkaline film on magnesium alloys has a fair mechanical adhesion, provided it is not too

Cleaning Methods for Magnesium Alloys

Type	Method	Use
Mechanical	By wire brushing, sanding, sand or grit blasting	Rapid removal of heavy dirt and oxide. Blasting should always be followed by acid-pickle.
Solvent	By rinsing or vapor degreasing	To remove oil prior to alkaline clean. As precleaning step for painting.
Alkaline	By hot soaking or electrolytic cleaning	Best method of degreasing for chemical treating. Will also remove old chemical finishes.
Acid pickle	By immersion	Usual cleaning step chemical coatings.

THE TWO LATEST WAYS TO PROTECT MAGNESIUM

FROM ENGLAND

Anodize It with Fluoride

MANCHESTER—Fluoride anodizing is a new process developed by Magnesium Elecktron Ltd of Great Britain—basically, it anodizes magnesium in a 10% solution of ammonium bifluoride. The process first removes cathodic impurities at the surface; and the essentially pure magnesium which remains is then given a film so thin (less than 0.0001 in.) that it causes no perceptible dimensional change. This adds corrosion resistance and promotes adhesion of subsequent paint films.

Although the film is protective and may not require further chemical treatment, it does not interfere with later chromate treatments.

Disadvantage is similar to other anodize process—magnesium parts with inserts of other metals cannot be treated unless they are completely masked off. The solution rapidly attacks and dissolves other metals and prevents anodizing of the magnesium itself.

FROM AMERICA

Coat It with Porcelain Enamel

MIDLAND, MICH—Porcelain enamel on magnesium, a protective method developed by the Dow Metal Products Co, offers excellent resistance to abrasion and chemical attack without permitting undercutting at bare or exposed edges.

Key to the system is a surface treatment that makes possible the use of standard lead oxide or lithium-phosphate frits as used on other metals. These porcelain enamels have completely protected magnesium-alloy panels against 20% salt spray for periods up to 500 hours.

The coatings have good heat-shock resistance—no spalling when quenched in water from 800 F—so promise wider applications for high-temperature parts such as engine components.

Porcelain enamels have been coated successfully on most magnesium alloys except those with high aluminum content and those of high total alloy content that contain low-melting eutectics.

old or thick. For moderate service life in dry environments, paints will adhere satisfactorily to the film. For example, aluminized and colored lacquers are currently used over bare magnesium to increase shelf life.

Pickling in acetic-nitrate or phosphoric acid gives a bright, metallic luster to magnesium alloys. The thin, slightly acid-to-neutral surface has better paint adhesion than the bare metal; however, films are too thin and too soluble to be durable in moist conditions. So these pickles are more commonly used as mill finishes prior to supplementary treatments.

Hot, concentrated chromic acid does not attack magnesium but will remove heavy oxide and scale. The bright metal surface is protected by an insoluble but thin transparent film which is more protective than the acetic-nitrate or phosphoric acid films. It is not sufficiently durable to maintain paint adhesion much beyond that obtainable from bare or acid-pickled surfaces.

Chromic acid activated by sodium nitrate (Dow No. 15), by nitric and hydrofluoric acids (Dow No. 16), or by ferric nitrate (Dow No. 21), produces insoluble, transparent chromic films which are sufficiently thick and durable to give good protection for short-term storage. In addition, they are good paint bases for lacquers and enamels. The bright metal luster which shows through a clear or tinted lacquer or enamel is an attractive finish for interior applications which require moderate resistance to moisture. Commercially, the ferric nitrate modification of these bright pickles is the most common because it has lower cost and longer bath life. It also is less likely to stain the parts if they are not thoroughly rinsed.

Chromate films—the most popular—are primarily hydrated gel-like structures consisting of amorphous, complex chromates. As applied, they are hydrophilic but become insoluble and hydrophobic. Aged chromate films on magnesium lose corrosion resistance, but are good paint bases, and more corrosion resistant when supplemented by chromated primers, with alkali-resistant vehicles. Adhesion is both mechanical and chemical.

In general, these films are stripped off by alkalis although heating tends to reduce this attack.

Under continuous wetting, for example, prolonged salt spray, alkali is formed rapidly and undercutting will occur at failure spots of the surface treatment or paint film (if the vehicle is alkali-sensitive). With alternate wetting and drying, undercutting seldom occurs. The basic magnesium carbonate film tends to dehydrate, forming a "cement-like" structure that resists wetting on subsequent exposures.

Acid Pickling Baths for Magnesium

Type	Used on	Removes	Dimensional change, in.
Chromic-nitrate	Wrought	Mill scale	−0.0005
Chromic-nitrate-hydrofluoric	Castings	Casting-skin segregation	−0.0005 to −0.001
Chromic acid	All forms	Flux, oxide corrosion products, chemical treatments	0.000
Phosphoric acid	HK31A castings for plating	Casting-skin segregation	−0.0005 to −0.001
Sulfuric acid	Castings	Effects of blasting	−0.002
Nitric-sulfuric acid	Castings	Effects of blasting	−0.002
Acetic-nitrate (ANP)	HK31A sheet for plating	Mill scale	−0.0005

Chemical Treatments

Dow No.	Treatment	Alloys Treated	Appearance	Uses	Remarks
1	Pickle	All alloys	Matte gray to yellow red	General-purpose, for protection during storage, good paint base.	Simple dip treatment, usually the cheapest etch, causes slight dimensional loss.
7	Dichromate	All alloys except HK31A, M1A, EK30A, EK41A	Brassy to dark brown	Good combination of paint base and protective qualities	Does not affect dimensions, requires ½ hr or more in boiling solution.
8	Alkaline dichromate	All alloys except HK31A, M1A, EK30A, EK41A	Brown black	Black finish	Paint base requires boiling in solution 1½ hr or more.
9	Galvanic anodize	All alloys	Black	Used on alloys which will not take Dow No. 7 or where a black coating is needed.	Requires galvanic connection between work and steel tank or steel plates; no external current required.
10	Sealed chromic pickle	All alloys	Matte gray to yellow red	Alternate for Dow No. 7 when dimensional loss can be tolerated.	Better protection than No. 1, requires boiling.
17	Anodize	All alloys	Clear to dark green	Excellent protective and decorative finish.	Best abrasion resistance, best paint base and most consistant of all Dow treatments for magnesium.
19	Dilute chromic acid	All alloys	Brassy to brown	Touch-up paint base, cheap commercial treatment.	Less critical touch-up than No. 1, good paint base.

This effect destroys the correlation between accelerated testing and actual service—giving poor performance in tests, but good service. Alkali-resistant vehicles in the primers and in top coats increase the over-all alkali resistance of the system and reduce undercutting.

Phosphate coatings, in general, are gray, porous films to which paint adheres almost wholly mechanically. However, because these films on magnesium are soluble and not inhibitive, they are recommended only for mild interior service. Heavy-metal salts, such as copper, nickel, iron, in phosphate baths, should be avoided since they can form cathodic materials, which accelerate corrosion. Such impurities are often present from contamination by using the same bath for treating metals other than magnesium.

Magnesium is anodized in the same steps as other metals —soil removal, deoxidation, and anodization. Both alkaline and acid anodizes are available. Unlike aluminum, anodic coatings on magnesium are dark, flat and opaque. For light colors, clear anodizes or bright pickles are used with tinted or dip-dyed lacquers. Alkaline anodize must be posttreated for paint adhesion but is harder and more wear- and abrasion-resistant than acid anodize. Acid anodize is more flexible, less subject to spalling or chipping, and makes an excellent paint base for the most severe corrosion. Commercially, anodic coatings are not too widely used because chemical conversion coatings plus a proper organic finish give excellent results and are cheaper.

PAINT CHEMISTRY

Paints are a complex mixture of resins, plasticizers, driers, pigments and solvents. Each of these contributes to the chemical and physical properties of final paint film, and any variation in formulation will generally change the properties. Though there are good formulations for specific applications, there is no one formulation that is good for all applications. Also, the composition of paints is highly proprietary and even within a given classification, variations in performance are observed from one paint to another, depending upon the way it was formulated.

For our purposes, a paint can be considered as a vehicle plus a solvent, with or without a pigment. If it cures by solvent evaporation, it is a lacquer. If further cure or polymerization occurs by oxidation, with a catalyst, or from heat, it is an enamel. If the purpose of the pigment in a lacquer or enamel is to inhibit corrosion, the paint is called a primer.

For magnesium, primers are usually formulated with chromate pigments such as strontium chromate, basic zinc chromate, zinc tetraoxychromate. Iron oxide (except when used with chromates) red lead, and carbon black are not recommended for this metal because they contain cathodic or potentially cathodic materials that will accelerate corrosion. For immersion in fresh water, titanium dioxide is preferred over the chromates since it is insoluble and therefore prevents blistering.

Primers perform two functions: they act as a carrier for inhibitive pigment; they promote adhesion of subsequent finishes. Relative importance of these varies with the particular metal. For magnesium, primers should be chosen on the basis of the alkali resistance of the vehicle and its ability to promote adhesion rather than for the corrosion resistance of pigment. (Currently available pigments in primers are only partly effective in protecting magnesium.)

Primers based on alkali-resistant vehicles allow the naturally alkaline film which forms on exposed metal in pores and scratches to supplement inhibitive pigments so that adhesion is maintained and corrosion is slowed. For magnesium, primers should contain an alkali-resistant vehicle of high polarity such as polyvinyl butyral, vinyl, epoxy, acrylic, polyurethane, and baked phenolics.

Primarily, the organic structure of the vehicle determines performance of the paint. (The pigments change performance less, but choice of colors should be reviewed with a qualified paint formulator.) When choosing a paint, the basic need is for the most economic film that

How Organic Vehicles Compare for Coating Magnesium

Resin	Chemical Resistance					Physical Properties				
	Alkali		Salt Spray	Gasoline	Chlorinated Solvents	Abrasion Resistance, cycles (Tabor test)	Max Service Temp, °F	Impact Resistance	Adhesion to	
	dil.	conc.							Mg	old paints
Alkyd	G	G	E	G	P	3500	200	VG	F	VG
Alkyd Amine	VG	G	VG	E	P	5000	250	E	E	G
Alkyd-urea	G	G	G	E	P	5000	225	E	VG	G
Styrenated Alkyd	G	VG	G	E	P	5000	200	G	E	VG
Alkyd Phenolic	F	P	E	E	F	5000	250	G	E	G
Alkyd Silicone	P	P	E	E	P	1000	1000	G	F	E
Acrylic	G	F	E	G	P	2500	180	E	VG	P
Bituminous	E	E	E	P	P	—	300	E	E	—
Nitrocellulose	P	P	E	G	P	2500	180	E	G	P
Butyrate	P	P	E	G	P	2500	180	E	G	P
Epoxy (100%)	E	E	E	E	E	5000	400	G	E	P
Epoxy Amine	E	E	VG	E	E	5000	400	G	E	P
Epoxy-urea	E	E	VG	E	E	5000	400	G	E	P
Epoxy Melamine	E	E	VG	E	E	5000	400	G	E	P
Epoxy Phenolic	E	E	VG	E	E	5000	400	G	E	P
Epoxy Ester	E	E	E	E	F	5000	300	E	VG	F
Fluorocarbon (air-dried)	E	E	E	F	P	1000	212	E	VG	P
Phenolic	P	P	E	E	G	5000	350	G	E	G
Polyamide (nylon)	G	G	F	G	—	—	300	VG	VG	—
Chlorinated Rubber	VG	F	E	G	P	5000	250	G	VG	E
Neoprene	E	E	E	F	P	5000	200	E	VG	—
Hypalon	—	—	E	P	—	—	250	E	VG	—
Silicone	P	P	E	VG	P	2500	1200	G	F	E
Urethane	VG	F	E	F-G	P	5000	300	E	E	F
Vinyl	E	E	E	E	P	5000	180	E	VG	G
Vinyl-alkyd (approx. 1:1)	G	P	E	E	P	2500	200	VG	VG	G

P-poor; F-fair; G-good; VG-very good; E-excellent

This table from data assembled by H. Rothenberg of Protective Coatings Inc

will maintain its integrity, physically and chemically, during prescribed service. In mild environment there is little effect on the metal, and vehicles are primarily chosen for economy and their physical properties. (Vehicles with fair to good alkali resistance are satisfactory. In severe service, metal chemistry becomes important; alkalinity of magnesium surfaces must be compensated for by vehicles with good or excellent alkali resistance. Therefore, it is in the more severe environments that magnesium finishing differs from other metals.

CHOOSING A FINISH SYSTEM

Finish systems for magnesium consist of a surface treatment suplemented by one or more coats of organic finish. Normally, applications subject to weathering or intermittent wetting and not requiring eye appeal, are used without any organic finish—for example, tooling plates and some automotive applications.

Choice of a finish system should be guided by those used successfully in application with the same service environment, service life, and physical and chemical exposure. For example, the finish successful on office dictating equipment should work equally as well on newer designs of the same equipment or on companion office equipment such as typewriters, and filing trays.

A given finish system may be applied to any alloy in the same family of metals. Surface treatments are usually modified to take care of variations in the alloy.

Estimated Finishing Costs for Magnesium

Based on large volume production. Includes labor and materials but not cost of capital equipment.

	Cost Range, ¢/sq ft
Cleaning Treatments	
Solvent cleaning	0.35– 1.4
Alkaline cleaning	0.35– 1.4
Acid cleaning	0.70– 2.1
Pre-clean for spotweld	1.4 – 2.8
Mechanical	
Polishing	2.8 –14
Scratch brushing	1.4 – 7.0
Satin finishing	1.4 – 7.0
Chemical Treatments	
Dow #19 (spray or roller)	0.9 – 1.8
Dow #19 (dip)	1.8 – 3.4
Dow #1	2.6 – 4.5
Dow #20	4.0 – 6.2
Dow #10	4.3 – 6.7
Dow #7	3.4 – 5.5
Dow #8	3.9 – 5.9
Dow #9	2.6 – 4.9
Ferric Nitrate (Dow #21)	2.2 – 4.0
Electrolytic Oxide Finishes	
Clear anodize	2.6 – 4.4
Dow #17 Thin	3.5 – 5.3
Dow #17 Full	6.2 – 8.2
Organic Finishes	2.0 – 4.0

Successful Commercial Finish Systems for Magnesium

	Desired Appearance	Sample Applications	Steps in a Typical Finish System
INTERIOR	Base metal	Interior components of appliances	As received
	Bright metal (shelf) Clear metallic	Dollies, ladders, griddles Tape-recorder reels	Bright pickle dip or ferric nitrate Clear anodize or bright pickle dip; metallized epoxy or acrylic
	Wrinkle	Dictating machines	Dow No. 1 or No. 19; standard wrinkle finish
	Crackle	Sewing-machine heads	Dow No. 1 or No. 19; standard crackle finish
	Smooth or textured leatherette	Card table, desks	Dow No. 1 or No. 19; clad with vinyl-coated fabric
	Smooth or textured leatherette	Vacuum-cleaner housings	Dow No. 1 or No. 19; vinyl organosol
	High-gloss enamel	Appliances	Dow No. 1 or No. 19; high-gloss baking enamel
	Metal pigment	Card-table chairs	Dow No. 1 or No. 19; bronze-pigmented epoxy
	Chromium	Drawer handles, tape-rule cases	Chrome electroplate
EXTERIOR	Base metal	Tooling plate, fixtures	Mill finish
	Bright-metal (shelf)	Wedges, masonry tools	Bright dip
	Wrinkle	Photographic equipment	Dow No. 1 or No. 19; AP-10 primer; polyvinyl butyral primer; standard wrinkle finish
	Aluminized lacquer	Furniture, materials handling	Dow No. 1 or No. 19; vinyl zinc chromate; vinyl or vinyl-alkyd aluminized finish
	Colored enamel	Lawn furniture, motor generator parts	Dow No. 1 or No. 19; polyvinyl butyral primer; baking enamel
	Smooth or textured leatherette	Luggage, carrying cases	Dow No. 19; clad with vinyl coated fabric
	Smooth or textured leatherette	Chairs	Dow No. 1 or No. 19; polyvinyl butyral primer; vinyl organosol
	High-gloss enamel	Chain saws	Dow No. 1 or No. 19; polyvinyl butyral primer; high-gloss enamel

Transposition of finishes from other base metals—aluminum, zinc, steel—to magnesium is more complicated. For mild indoor applications, specific considerations for magnesium are not always necessary. However, for outdoor applications, particularly marine (chloride) atmospheres, metal chemistry becomes very important. For example, in many exposures where bare aluminum may perform satisfactorily, magnesium will lose its metallic luster and require either a bright dip or metallized lacquer. If a longer life and a black wrinkle finish are desired, aluminum and magnesium may be given essentially the same treatment—a chromate dip plus a wrinkle finish.

As we progress into exterior, and more severe atmospheres, the finishing of magnesium becomes specific, resembling that of steel more than of aluminum or zinc. Here, finishes for severe environments or long service require alkali-resistant treatments and alkali-resistant vehicles in the primer and top coats. The slight alkalinity of aluminum and zinc surfaces, plus their low corrosion rates, allows using non-alkali-resistant vehicles—these metals, unlike magnesium, do not form alkali at sufficiently high rates to destroy the chromate film or saponify an ester vehicle. Thus, adhesion can be maintained on aluminum and zinc which would be destroyed by the large amounts of alkali formed on magnesium.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Products Engineering, 330 W 42nd St, New York 36, NY.

EDITOR'S NOTE: Other protective finishes and methods for applying them are discussed in these articles:

Plating Parts by Peening Them. Mar 14 '60, p 70—plating parts with powder in a tumbling barrel is a cheap way to coat with zinc and other metals.

Specifications for Anodized Finishes, Sep 28 '59, p 44—practical guide to specifying aluminum alloy finishes.

New Look in Porcelain Enamel, Nov 24 '58, p 53—coating with porcelain enamels is no longer as simple as just picking a gleaming color or one of the new patterns. It's also important to know engineering properties required.

Color and Textures for Aluminum, Sep 30 '57, p 101—evaluates surface treatments and coloring methods which provide wide scope for attractive product identification.

for fledgling engineers—

A SHORT INDOCTRINATION PROGRAM

When this plant closed for vacation two weeks during the summer, newly hired engineering graduates took over to learn rudiments of company aims and procedures.

LOUIS J FRANGIPANE
Supervisor, Systems Administration
Kearfott Div of General Precision Inc

Most of this June's engineering graduates will be spared the traditional long step from cloistered academic atmosphere to challenging industrial climate, thanks to the growing popularity of an industry-developed cushion. This cushion is the in-plant training program, an indoctrination course conducted by most of today's manufacturing firms. In 1957, a survey made by a study group at Harvard University showed that 88% of companies hiring engineers offered this kind of training. And recent estimates indicate the percentage is now even higher. Recruiters find that such a program helps draw more candidates, and company executives justify the expense by arguing that the neophyte develops more quickly into a contributing member of the technical staff.

How long should the training program last and how should it be conducted? There are as many answers as there are companies. Established programs vary in length from a few weeks to several years; in degree from a formal, rigidly academic pattern to an informal, on-the-job affair. The Kearfott Div of General Precision found its answer in a short, formal program tried for the first time last year. The approach is unique and stimulating for the new engineer, yet it satisfactorily meets the goals of any good program—to familiarize the newcomer with the company's methods as quickly and thoroughly as possible.

Make-believe problem

This program started more as a matter of convenience than direction. Each summer, the plant is shut down for two weeks at the end of July for a company-wide vacation period. But new employes—among them the recently hired graduates—do not yet qualify for a paid vacation. Rather than send the new graduates home, management suggested they be put to work on a problem and thus given a chance to exercise their engineering skills while learning established routines.

For this first trial program, problems were chosen from the government publication, "Inventions Wanted by the Armed Forces." The list was narrowed to about 10 problems considered to be in the company's general field of interest. (This year it is planned to collect a number of actual company problems for consideration by the group.) Last year the class of 28 engineers was divided into groups of 5 or 6, and each group chose a problem. These problems were developed from conception to marketing in much the same way a real problem would be carried through the company machinery. A skeleton crew of key engineers and clerical workers was on hand to help them with problems outside their own department.

Creativity is theme

The framework of the program is patterned after the creative approach to group problem-solving suggested by E. K. Von Fange of General Electric Co and consists of these 8 steps.

1. Recognize existence of the problem.

2. Define problem and list specifications the final product must meet.

3. Search for solutions by encouraging a free flow of ideas from the group.

4. Evaluate suggestions both for individual merit and possible combinations.

5. Select best solution on basis of cost, producibility, sales appeal, resistance to environmental hazards, etc.

6. Develop a preliminary design with sketches and sufficient information to show it's a practical solution.

7. Demonstrate the product and report on its design or operation.

During the two-week period, mornings were devoted to

MORNING SESSIONS

First Week

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Introduction and objectives Fundamentals and techniques of creativity First sample problem	Teams formed Second sample problem Lecture on technical writing	Lectures on: proposal writing, company organization Discussion of problem assignments	Team activity: define problem and search for solution	Evaluation and selection of ideas Oral progress report Reference work

Second Week

Lecture on technical speaking How to prepare a presentation	Preparation for presentation	Presentation, teams 1 and 2	Presentation, teams 3 and 4	Presentation, team 5 Reports due Summary and conclusion of program

discussions and lectures to the class as a whole; afternoons were set aside for individual study and activities of individual groups. The first two mornings, the class was briefed on the organization of the company, the use of the library, the form of technical reports and proposals. During these early stages, the trainees were also given an opportunity to try their hand at a couple of sample problems which they proceeded to develop as a group.

At end of the first week, each group had carried it's own special project through to the stage where it had selected a solution. At this point, staff positions such as project engineer, sales engineer, market researcher, metallurgist, were delegated on a voluntary basis to assist development of the idea to the preliminary design stage.

The first afternoons of the following week were spent in research. Most trainees went to the company library; others consulted with the purchasing department. Still others visited the laboratories, introduced themselves and sought help from senior staff members. Potential vendors were queried by phone and parts catalogs saw constant service. Several class members went to the public library for special reference work. A competitive spirit developed, inspiring a lively interest within the groups.

After two days the fledgelings brought their fully developed product to class in the form of drawings and cost estimates, and attempted to "sell" it to the group. While the rest of the class acted as management, each member of a team reported on his contribution to the project. Each group had a chairman who introduced each of its members, summed up the presentation, and invited questions. Here, individuals had good practice answering questions of the kind that occur in engineer-management and engineer-customer relations. The presentations lasted three days. Visual aids, the blackboard, and references that justified estimated costs were used extensively. At end of this second week each group submitted a technical report in the style and method explained to them earlier.

Organizers of the program feel it has many direct benefits:

- New engineers are alerted to the need and method of being creative.
- They gain experience as part of a design team.
- In selling their contribution to "management" they have an opportunity to speak before a critical audience.
- They become familiar with the engineering department, the staff of experienced engineers, purchasing agents and others.
- They become familiar with the library and the function of other service organizations.
- They gain experience in technical writing.

EDITOR'S NOTE: For more on creativity and the personality traits that distinguish creative persons, see:

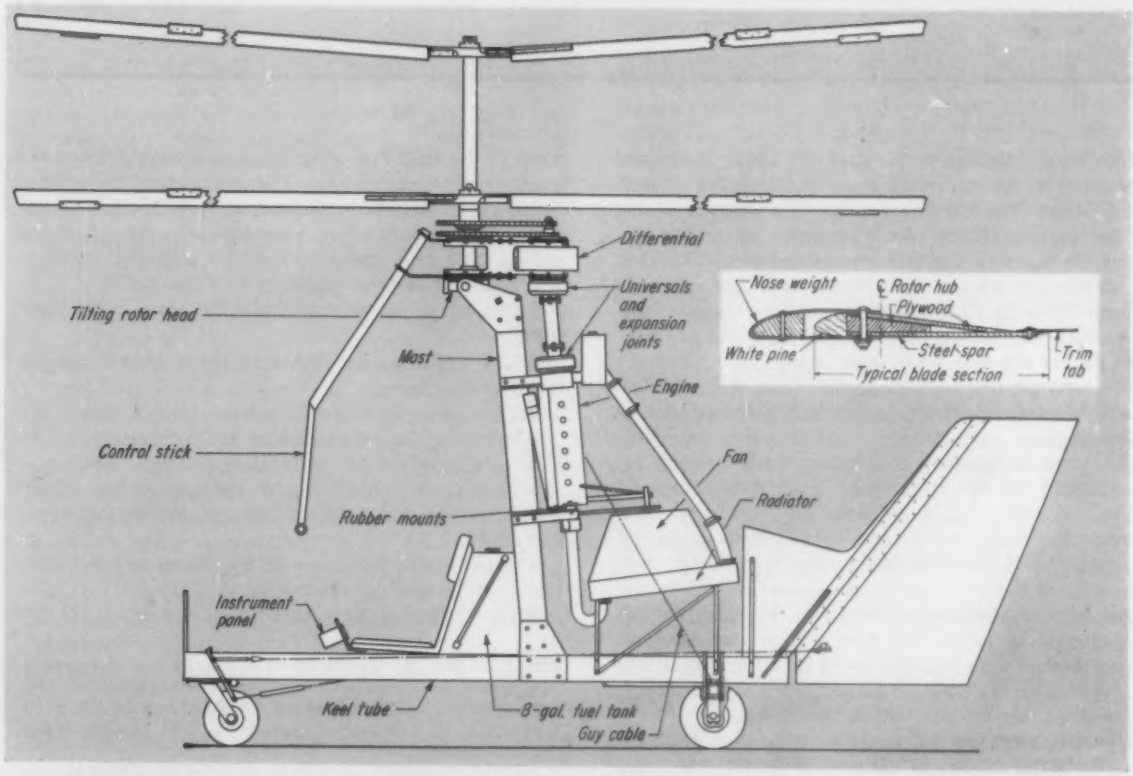
Creativity . . . Facts Behind the Fad, Aug 24 '59, p 20. A summary of information brought to light at a three-day Harvard conference on creativity.

Are You Creative? Nov 17 '58, p 28. A psychologist lists traits, both social and personal, common to most creative people . . . his wife illuminates each trait with a personal note.

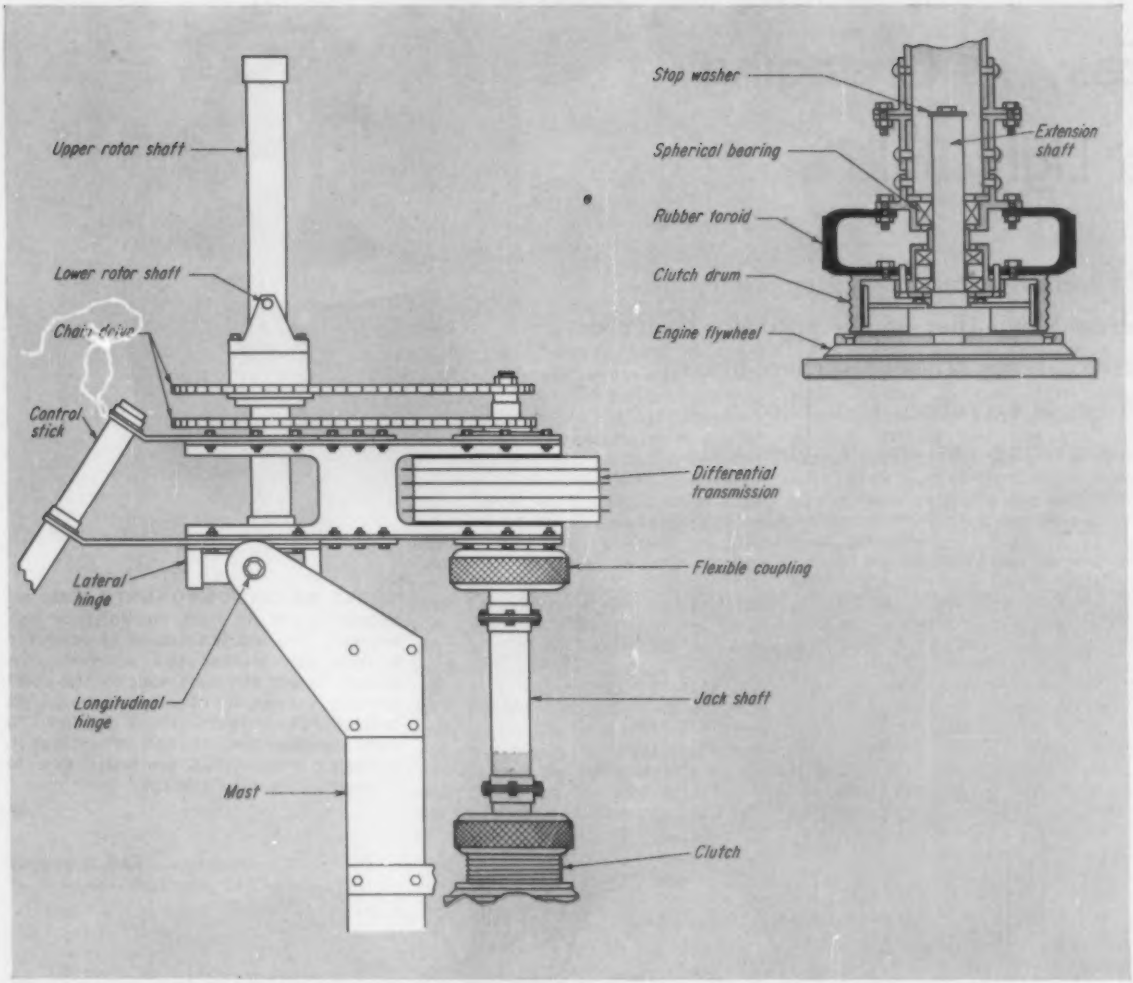
Can You Spot a Creative Engineer? June 16 '58, p 30. A checklist of unusual attributes of creative people, suggesting that creativity doesn't necessarily wear a tweed jacket and smoke a pipe.

An Outboard Goes Flying

Keynote of this copter is simplicity. Chain-drive rotors run off a 60-hp outboard motor, and bolted construction gives rugged assembly low cost.



THE AIRFRAME consists of three rectangular tubes bolted together for quick assembly and disassembly. No welding or brazing is required in the primary structure. Engine, transmission, and rotor head are mounted on the mast. Guy wires attached to the axle tube are used to brace the mast. Cross-hinge at masthead permits rotor shafts, differential transmission and reduction drives to tilt as a unit for 360° directional control. Using a pair of counter-rotating coaxial rotors eliminates the tail rotor usually required on single-rotor helicopters. The laminated rotors are built around a steel spar. Nose weight is used to bring blade center of gravity to 25% of its chord. Trim tab is bent to adjust tracking of blades. Accurate blade tracking is required to prevent rotor vibration.



POWER PACKAGE is built around a 6-cyl watercooled outboard engine that transmits power through a 2-shoe centrifugal clutch. A jack shaft with flexible couplings at each end drives the differential transmission. The rubber toroid flex-couplings permit angular misalignment plus variations in distance between transmission and clutch when the rotor head is tilted. Spherical bearing on the extension shaft keeps jack shaft in line and carries side thrust when rotor head is tilted. Stop-washer limits elongation of couplings. Final speed reduction is by chain and sprocket drive to the concentric rotor shafts.

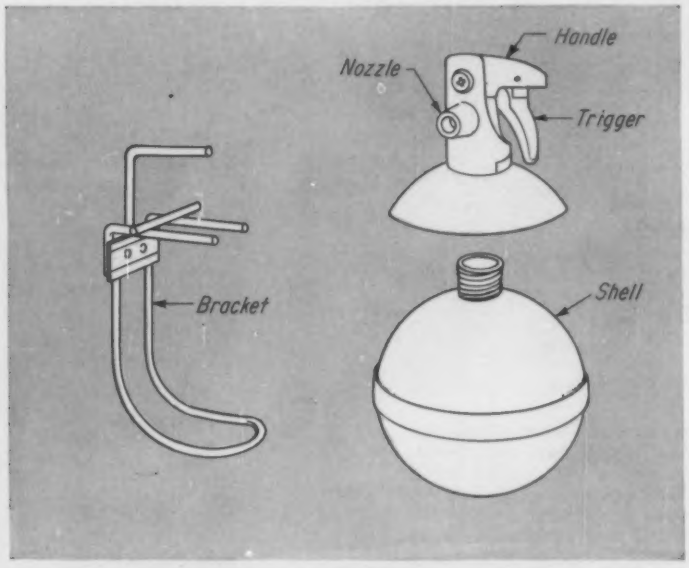
PS . . . The "Little Zipster" is a true helicopter, can fly in any direction and ascend or descend vertically. Except for high strength AN bolts, all materials are commercial quality. The one-man rotorcraft is powered by a Mercury MK75 6-cyl outboard engine using standard automotive gasoline. Bensen Model B-9 Helicopter is produced, fully assembled or in kit form, by Bensen Aircraft Corp, Raleigh, NC.

Specifications

Rotor Dia.	22.0 ft
Gross Wt.	700 lb
Useful Load	250 lb
Engine	Mercury MK75
Horsepower	60 hp
Cruising Speed	60 mph
Hovering Ceiling, IGE	6000 ft
Absolute Ceiling	12,500 ft
Endurance	2.0 hr
Range	100 mi

Easy as Changing a Light Bulb

To recharge this fire extinguisher, just screw in another of the specially designed steel spheres. They're furnace-brazed in single operation, then filled with pressurizing gas and dry chemical.



THREE MAJOR COMPONENTS of the extinguisher are its shell, control head and bracket. The unit is actuated by removing it from the bracket and squeezing the trigger. A pin pierces a disk on the shell, allowing gas and dry chemical to discharge. Releasing the trigger shuts off the flow. To recharge—unscrew the shell and replace it. Mounting bracket has protective arm to prevent accidental discharge.

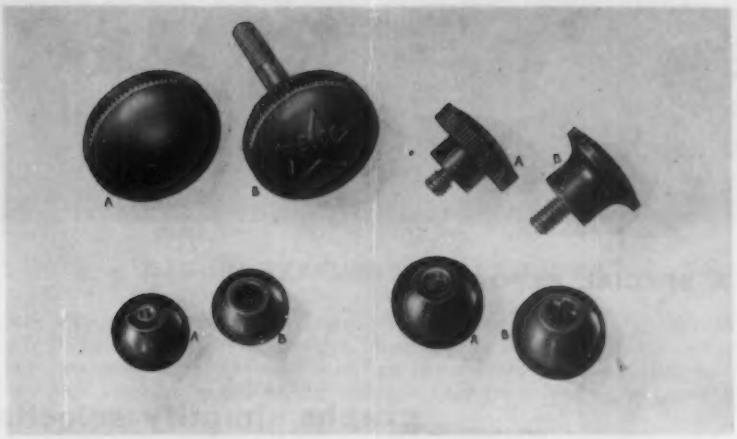
DISPOSABLE SHELL consists of two stamped hemispheres and threaded connection plus pressure-pickup tube and pressure seal, all furnace-brazed into one unit. Steel sphere was selected because it is simple to form and join, is low cost, has maximum volume for area occupied, and is the strongest shape for containing pressure. Charging pressure is 190 psi, air-leak and strength tests are run at 570 psi and rupture pressure is above 1140 psi. Leak-testing system used detects seepage equivalent to ¼ oz in 20 years.

Control head is fabricated from aluminum diecastings. Copper-free alloys and an iridite coating provide excellent corrosion resistance. All exposed working parts and fasteners are stainless steel (18-8). Square-wire torsion spring holds the valve normally closed; valve also acts as stem-puncture pin. Valve disk is neoprene. Bracket is a welded-wire assembly with contact areas dipped in white vinyl to prevent abrasion. Wire bracket can resist a force of over 6g to prevent accidental release.

PS . . . Dual goal for extinguisher design was, (1) low cost, (2) an Underwriters' Laboratory rating of 4-B:C (8 times as effective as a pump-type extinguisher filled with carbon tetrachloride). Four specific requirements therefore had to be met; elimination of the usual pressure gage; steel shell that could be inexpensively brazed; shell to be disposable tooling designed for high production rate from the start. "Monitor" fire extinguisher is produced by Ansul Chemical Co, Marinette, Wis.

CUSTOM KNOBS

...needn't carry a custom price tag if molded with reworked off-the-shelf tooling



FOUR CASE HISTORIES illustrate how stock, catalog knobs can be modified to meet your specific product needs.

1. Knob at upper left (A) was modified (B) for a manufacturer of electrical equipment who needed a threaded fastener with a long shaft for clamping a panel to the front of a large power transformer. And because of the knob's prominent position on the equipment, the manufacturer further specified that its face carry the company monogram. A new set of force plugs gave the needed changes. Tooling cost was $750 compared to $4000 for a custom-made mold.

2. At upper right, reworking the mold for a thumb screw (A) gave a knob for an air valve (B). For push-pull operation, the knurling was not required and more clearance was needed under the flange. The new set of cavity blocks cost $550; a custom mold would have cost about $2000.

3. For a hydraulic-valve pushbutton, a manufacturer needed a round red knob similar to the stock black phenolic knob shown at lower left (A). A new stripper pin was the only change required. It gave a large cored hole (B) in place of the threaded insert on the stock part. Tooling cost, $100; estimated price of a completely new mold, $3000.

4. A manufacturer of lawnmowers needed a round knob (lower right) the size and shape of a stock part (A), but with a rectangular hole (B) to fit a flat control lever. Changing the threaded hole to a rectangular one required a new stripper pin. But the molder felt that a slender pin might bend out of alignment under mold pressure and suggested a cross-shaped hole and pin. These complicated pins cost the lawnmower maker $350, about one-tenth of the cost of a comparable custom mold.

ROBERT K GRAY, *chief engineer*
The Dimco-Gray Co, Dayton, Ohio

Today's increasing emphasis on product appearance is making the knob more than a functional component. To the stylist it is also an ornament, a place to display the company monogram, a decorative unit that accents the shape and color of the package. Knobs that do such styling jobs effectively can't be ordered from a catalog. But this doesn't mean you have to pay $2000 to $5000 for a special mold (a prohibitive price when quantities are small). Chances are, the molder of the catalog knobs can meet your individual specifications by making small modifications on one of his stock molds.

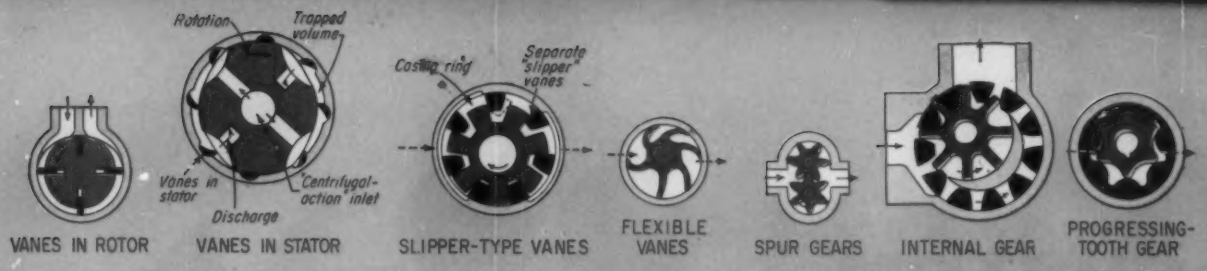
The contours of a compression-molded plastic knob are determined by a four-piece mold cavity. Two plugs form the face and undersurface of the knob. A cavity block determines its diameter and external contours. The fourth part is the stripper pin; it projects into the cavity to leave a hole in the knob's underside.

A change in any of these parts can effect a considerable change in the shape of the knob and cost of these modifications is appreciably less than that of a new mold. New force plugs, for example, may cost from 15 to 30% of custom-mold cost; new stripper pins, from 2 to 10%. Special colors and materials require no change of tooling. Black phenolic knobs are standard but other colors and other materials (members of the melamine, urea, and polyester families) can be formed in the stock molds at a cost dependent on the material.

Generally the molder keeps the parts of your special-order mold even though you have paid the tooling charge. But if the new mold fills a vacancy in his line or has future sales possibilities, he may share a part of the rework cost.

Lower cost is not the only reason for specifying a modified stock knob. Because preparation for tooling is minor, the stock molder can usually deliver within 45 days while the custom molder may need 3 to 4 months.

Also, because the stock molder produces a larger volume of closely similar parts, he buys materials (such as metal inserts, setscrews, etc.) in quantity and molds the knobs on automatic or semiautomatic machines. These savings can be passed on to the customer. ■



A SPECIAL REPORT

graphs simplify selection of

POSITIVE-DISPLACEMENT PUMPS . . .

these easy-to-use charts quickly give values for power, efficiency and suction. Author also compares positive-displacement pumps with other basic types such as centrifugal, listing advantages and limitations of each.

Dr Warren E Wilson, *chairman, Engineering Dept., Harvey Mudd College, Claremont, Calif*

When you need a positive-displacement pump, don't waste time searching through dozens of catalogs—just use the charts given here. They quickly give the answers needed to choose the right pump of this type, and also help predict its performance.

The charts for output power and suction head apply to all common positive-displacement pumps (gear, vane, piston, lobe and screw). Efficiency charts have been prepared for the gear, vane and piston types (detailed efficiency data not available for the other types).

Of course, before consulting the charts make sure it's a positive-displacement pump you need. For guidance, here are the advantages and limitations of all basic pump types, together with suggestions for choosing the right one.

ABOUT THE AUTHOR

Dr Warren E. Wilson, who is both engineer and educator, has been president of South Dakota School of Mines and Technology, engineering consultant to numerous pump companies, Pratt Institute's dean of engineering, and is now chairman of the engineering department at Harvey Mudd. He also organized the National Conference of Industrial Hydraulics in 1945.

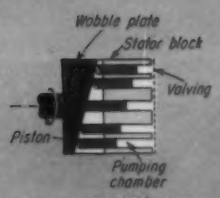
Positive-displacement pumps in general have good volumetric efficiency. They can develop high pressures (to 10,000 psi), produce flow that is directly proportional to speed, and prime themselves, even at very low inlet pressure. But they must not be started or operated with the discharge valve closed; low-viscosity fluids increase the slip, and abrasive fluids cause wear. (A centrifugal pump is usually better than a positive-displacement pump at low discharge pressures.)

Of the positive-displacement pumps, the piston type has highest volumetric efficiency because leakage path between piston and cylinder can be closely controlled in manufacture. Vane, screw and lobe versions have the best suction characteristics, and are least likely to cavitate. Many unusual types of positive-displacement pumps are available with special characteristics. A few are shown among the 17 sketched above and on facing page.

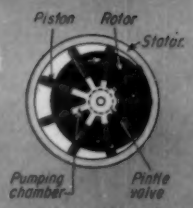
Centrifugal pumps—at least, those that are most common, which are single-stage—rarely exceed 100-gpm flow or 100-psi discharge pressure. Larger sizes—single and multistage—for pipelines and other applications are available, but are often custom-made. For centrifugal pumps in this article, the product of flow and the pressure, gpm × psi, is assumed not to exceed 5000.

The output pressure of centrifugals depends on pump

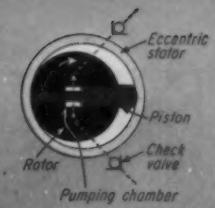
text continued on page 44



AXIAL PISTON

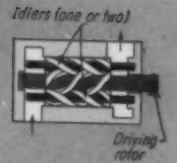


RADIAL PISTON

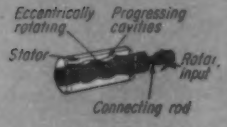


ECCENTRIC-RING PLUNGER

INTENSIFIER PISTON

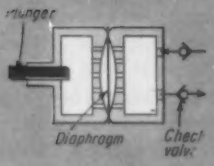


MULTIPLE SCREW



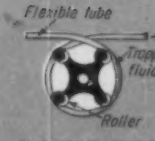
SINGLE SCREW

LOBE



DIAPHRAGM

FLEXIBLE LINER



FLEXIBLE TUBE

DESIGN FEATURES OF 17 TYPES

All positive-displacement pumps—including the unusual types—have one thing in common: the liquid is forced out by reducing the volume of the pump enclosure. They differ in how the volume is reduced, and how the high-pressure liquid at the outlet is kept from leaking excessively to the inlet.

VANE PUMPS

VANES-IN-ROTOR version is most common; vanes move radially to follow pump contour. Leakage from outlet to inlet across top is kept small because vane is completely retracted, rotor-to-stator clearance is practically zero.

VANES-IN-STATOR PUMP has hollow-shaft inlet; centrifugal action reduces cavitation. Pumping occurs as rotor turns because trapped volume of liquid is squeezed out by vanes. Outlet is through rotor—flow leaves rotor via sliprings.

SLIPPER-VANE PUMP initially depends on centrifugal force to throw slippers against casing ring. But then liquid pressure, viscous drag, and oil-film cohesion hold vanes in position. Action is similar to that in Kingsbury thrust bearing.

FLEXIBLE-VANE PUMP depends on bending of vanes to decrease trapped volume, force out liquid.

GEAR PUMPS

SPUR-GEAR PUMP carries trapped liquid between pairs of outer teeth, forces it against existing outlet pressure. Outlet-to-inlet leakage is kept small by close-meshing teeth at center.

INTERNAL-GEAR PUMP is similar to vane pump in operating principle. Inlet liquid fills expanding pumping cavities, is carried around inner and outer path as shown. Outlet-to-inlet leakage is kept small by close-meshing spider teeth and vanes.

PROGRESSING-TOOTH GEAR PUMP has one less tooth in rotor than in stator, thereby moving trapped volume one tooth width each revolution. Performance is similar to vane pump.

PISTON PUMPS

Piston pumps have reciprocating action that allows inlet liquid to fill cavity on suction stroke, forces it out on pumping stroke.

AXIAL-PISTON PUMP depends on beveled "wobble" plate or equivalent off-center linkage system to reciprocate pistons. **RADIAL-PISTON PUMP** depends on eccentric stator (or rotor) to give reciprocating action.

ECCENTRIC-RING PLUNGER PUMP is single-piston version of radial-piston pump. It is shown in suction position; 90-deg rotation of rotor will close pumping chamber, forcing out liquid.

INTENSIFIER-PISTON PUMP transfers energy from one liquid system to another. Version shown converts high-volume low-pressure fluid (large chamber) to low-volume high-pressure fluid (small chamber).

SCREW PUMPS

MULTIPLE-SCREW PUMP drives through single rotor; the other meshing rotors (there can be one or more) help trap liquid in pumping cavity that moves axially as the rotor turns.

SINGLE-SCREW OR "PROGRESSING-CAVITY" PUMP has helical rotor rotated by connecting rod. However, rotor not only rotates about its own axis, but its own axis rotates relative to axis of input. This eccentric action keeps rotor in constant contact with stator, trapping liquid in axial-moving cavity.

LOBE PUMPS

LOBE PUMPS of simplest design are similar in operation to spur-gear pumps—liquid is carried in outside pockets.

DIAPHRAGM PUMPS

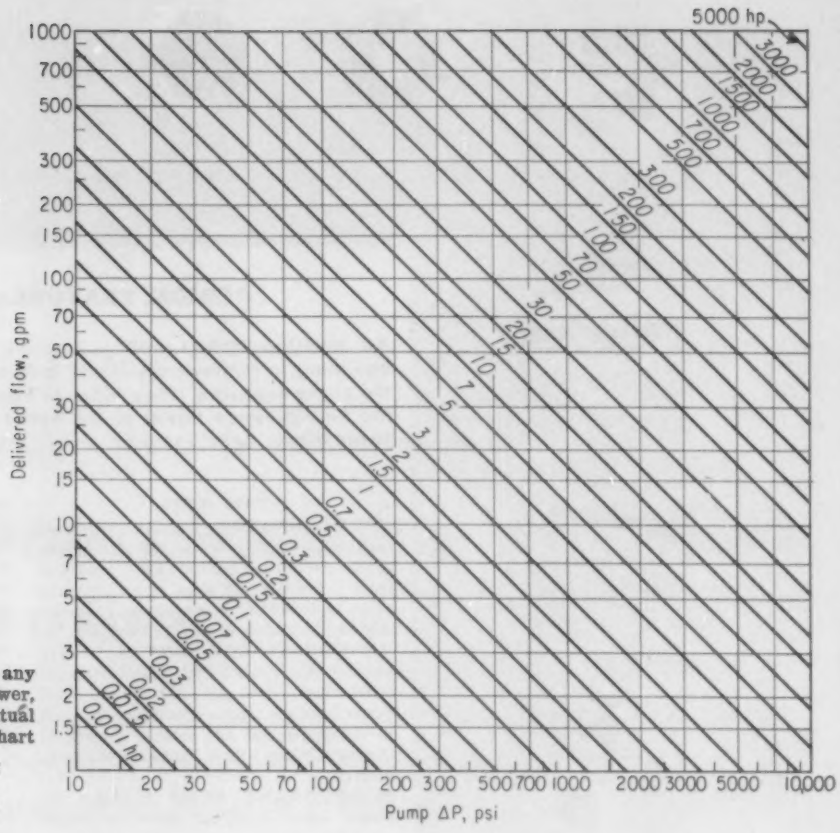
DIAPHRAGM PUMP shown transfers energy from plunger-driven fluid on left to pumped fluid on right. The amount pumped is equal to displacement of the plunger. Other versions can have cam-operated diaphragms.

SQUEEGEE PUMPS

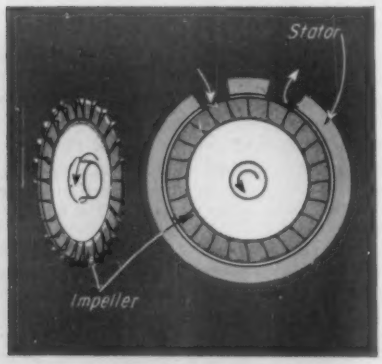
FLEXIBLE-LINER PUMP traps liquid in "squeegee" action. Pumping and sealing stops as eccentric goes through top dead center, but momentum of fluid prevents backflow. Principle advantage of squeegee is isolation of moving element from pumped liquid.

FLEXIBLE-TUBE PUMP is also squeegee type, but multiple rollers keep liquid trapped at all times.

POSITIVE-DISPLACEMENT PUMPS continued



THEORETICAL POWER to drive any pump equals output fluid horsepower, $5.82 \times 10^{-4} Q_d \Delta P$, plotted here. Actual power required to drive pump is chart hp divided by over-all efficiency.



TURBINE PUMP is neither centrifugal nor positive-displacement, but has some characteristics of each. Pressure rise depends on momentum given to liquid by the spinning rotor.

geometry and speed of rotation. These pumps have a limited range of shaft speeds, and cannot tolerate as much cavitation as other types. They perform best with low fluid viscosities and are better suited for transporting fluid than building up high pressures. Abrasive or dirty fluids can be easily handled by a properly designed centrifugal pump. However, in basic hydraulic power-and-control systems, pressure is the essence of operation, and positive-displacement pumps are usually recommended.

Propeller pumps (axial flow) and mixed-flow pumps (partly centrifugal, partly axial) also have output pressure dependent on geometry and speed of rotation; have same limitations as centrifugals.

Turbine pumps combine elements of the centrifugal and positive-displacement types. The theory behind this type is not fully understood (although we do know that flow is produced by momentum transfer of turbulent liquid). But performance is well known—discharge pressure responds somewhat linearly with speed, as it does in a positive-displacement pump. Discharge pressure is usually less than 300 psi in a single stage, but this is higher than that of a single-stage centrifugal. Low-viscosity fluids, such as water, gasoline, and alcohol—even at low suction pressures—can be easily handled.

Turbine pumps are not too efficient—about 40 to 50% over-all—but their design simplicity overcomes that objection when efficiency is not a primary requirement.

IMPORTANT PUMP EQUATIONS

Pressure	$\Delta P = P_{out} - P_{in}$
Flow	$Q_d = Q_i - Q_s - Q_c$ $= E_v Q_i$ $Q_i = ND$ $Q_s = C_s D \Delta P / \mu$
Torque	$T_m = T_i + T_F$ $T_i = 36.8\ D \Delta P$
Power	$hp_{in} = 1.585 \times 10^{-5}\ TN$ $hp_{out} = 5.82 \times 10^{-4}\ Q_d \Delta P$
Efficiency	$E = hp_{out} / hp_{in} = E_v\ E_T$ (varies with $\mu N / \Delta P$) $E_v = Q_d / Q_i$ $E_T = T_i / T_m$

SYMBOLS FOR EQUATIONS

PRESSURE AND HEAD

P	Pressure, psi (P' = psf, P_v = vapor pressure)
H	Head, ft of liquid
Z	Elevation of inlet above pump centerline, ft
NPSH	Net positive suction head, ft

TORQUE

T	Torque, lb in (subscripts: m = driving; i = ideal; F = friction, dry and viscous)

FLOW AND DISPLACEMENT

Q	Flow, gpm (subscripts: d = delivered; i = ideal; S = slip; C = cavitation)
N	Speed, rpm
V	Velocity, ft/sec (subscripts: 1 = inlet; 2 = pumping chamber)
D	Displacement, gal / rev

POWER AND EFFICIENCY

hp_{in}	Power to drive pump, hp
hp_{out}	Power output (liquid), hp
E	Over-all efficiency, % (subscripts: v = volumetric; T = torque)

COEFFICIENTS AND CONSTANTS

C_S	Coefficient of slip
g	Gravity constant, 32.2 ft / sec^2
μ	Absolute viscosity, slugs / (ft x sec) or lb_{force} x sec / ft^2
SSU	Kinematic viscosity, Saybolt seconds, universal
ρ	Mass density, slugs / cu ft
R	Outlet restriction (pump load), psi per gpm

Jet pumps, pitot-tube pumps, and other basic types are used for certain specialized applications. The jet type —common in well-pumping applications—entrains liquid from a low-pressure area into a jet of liquid that has high velocity head and low static head. A pitot-tube pump rotates a body of liquid in a cylinder, taps off total pressure via a stationary pitot tube inserted in the outer area where pressures are highest.

POWER AND EFFICIENCY CHARTS

Theoretical Output Power

The nomograph on previous page gives pump-output hp for any given flow at any given pressure. Actual power to drive pump will, of course, be greater than the output power; it depends on over-all efficiency of pump. The relationship is $hp_{out} = E \times hp_{in}$, where hp_{in} is power needed to drive pump, E is over-all efficiency of pump, and hp_{out} is theoretical pump-output hp based on flow and pressure.

Over-all Efficiency

Pump efficiency depends on too many variables to allow easy calculation. Typical variables are internal backflow (slip), cavitation, and friction (dry and viscous). However, pumps of similar design tend to follow the same pattern of losses and these can be estimated with "averaged" data, such as those on next page.

Volumetric efficiency—an important part of over-all efficiency—is ratio of delivered flow to ideal flow. Delivered flow $Q_d = E_v DN$, where E_v is volumetric efficiency, D is displacement, and N is pump speed. Volumetric efficiency depends on shape and clearance of rotating and stationary elements, suction characteristics of pump, viscosity of liquid, speed and pressure of pump.

If clearances are small and there is good dynamic sealing between rotor and stator, internal backflow will be small, volumetric efficiency high. But this assumes pump inlet is kept pressurized and full, so cavitation (see suction-head section, page 48) does not reduce delivery.

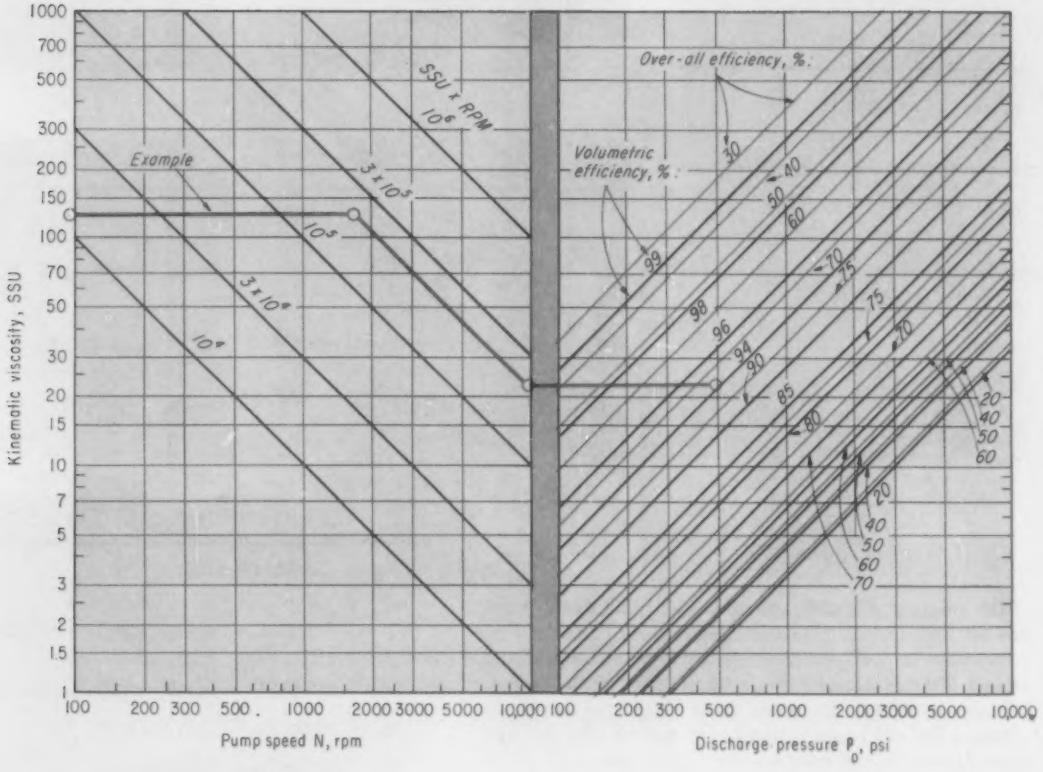
Viscosity of the liquid has a pronounced effect on volumetric and over-all efficiency, and also on friction load and cavitation. The effects are opposing: high viscosity helps reduce slip (improving the volumetric efficiency) but increases friction load and hinders suction. Low viscosity improves suction and decreases friction load but increases slip (lowers volumetric efficiency).

Slip (internal backflow) in gpm tends to conform to this formula for viscous flow between two flat plates: $Q_s = K \times (\Delta P / \text{viscosity}) \times (\text{width/length}) \times (\text{clearance})^3$, where K is proportionality constant. Note that both width and length of clearance path can be increased without changing absolute slip flow—if width-to-length ratio and clearance are held constant.

Actual pumps, however, do not have predictable leakage-

text continued on page 48

GEAR PUMPS



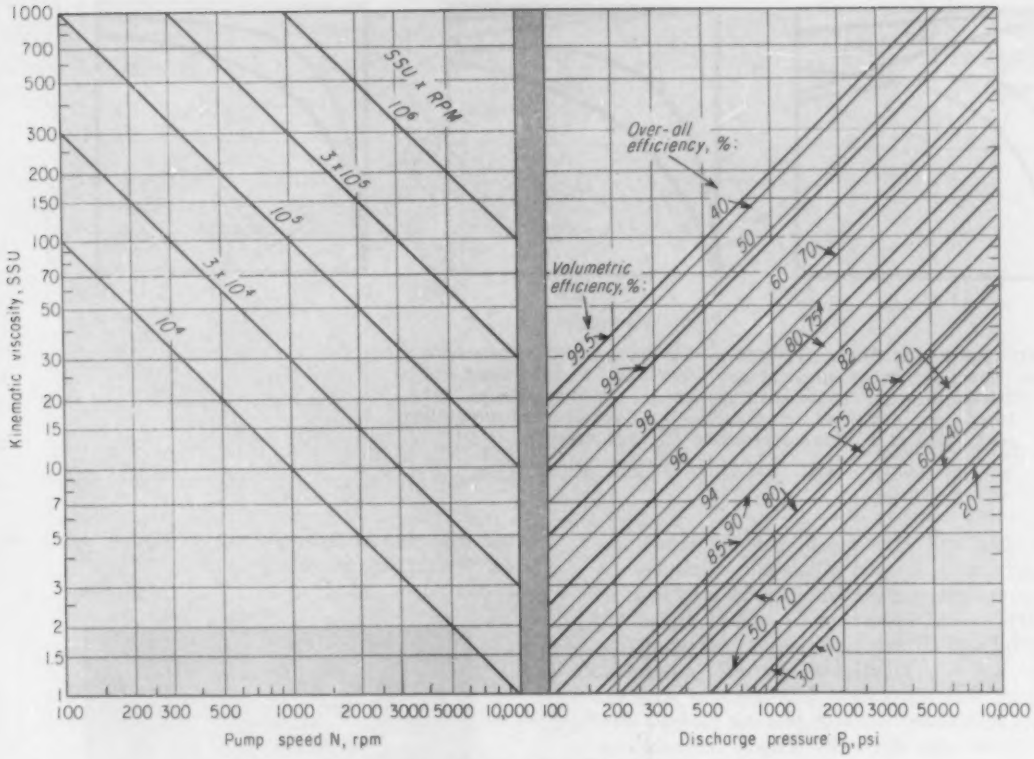
OVER-ALL EFFICIENCY and volumetric efficiency of gear, vane and piston pumps can be quickly estimated with these three nomographs—based on actual data from many pump tests. Plotting method assumes slip coefficient C_s is constant for each type pump, and $Q_s = C_s D \Delta P/\mu$. Dry friction is neglected because a well-designed pump has very little. Viscous drag is assumed proportional to speed and viscosity. Value for discharge pressure assumes inlet at atmospheric pressure. Oil used has specific gravity of 0.8, and is at normal operating temperatures.

Accuracy of these charts is probably little better than ±20% for most pumps because manufacturing and design variations are great. Better accuracy is possible if one or more performance points are known—effects of speed, viscosity and pressure can be easily predicted using charts.

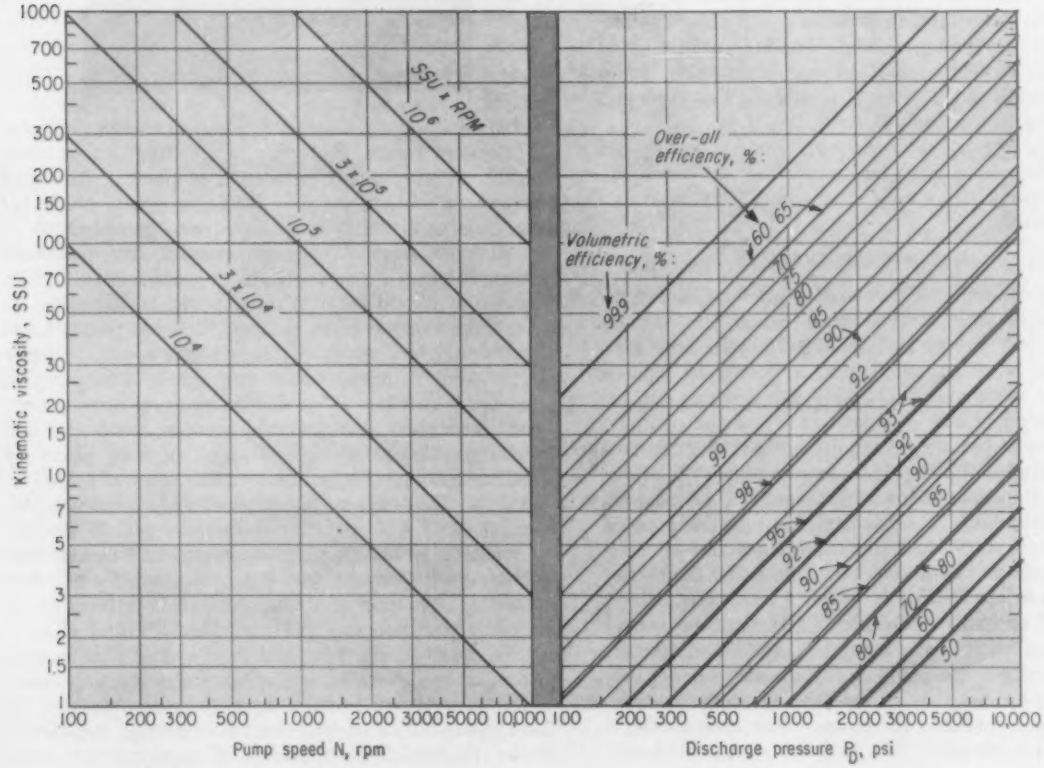
Here is an example: oil at 130 SSU is pumped to 500 psi with 1800-rpm gear pump. What is probable over-all and volumetric efficiency? Answer: 94% volumetric, 72% over-all. Note: raising viscosity to 500 SSU will increase volumetric efficiency to over 98%, lower over-all to 45%. Best efficiency point can be found by trial and error.

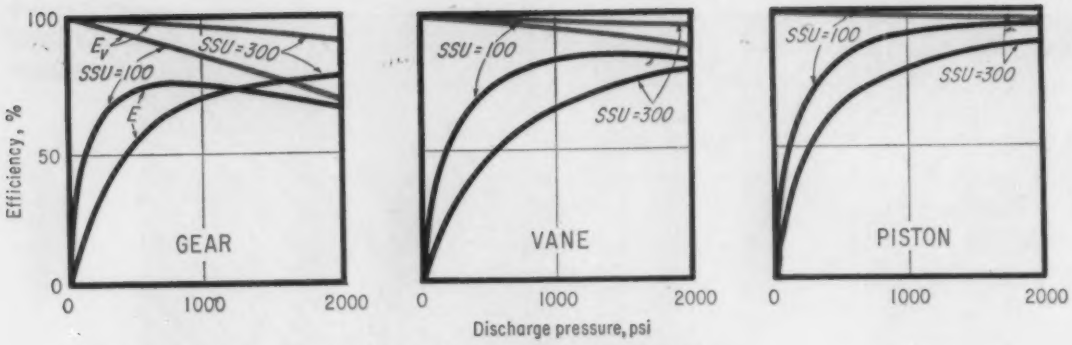
Another example: pick gear pump to pump 1000-SSU liquid to 600 psi discharge. The best over-all efficiency is 76%—coinciding with horizontal line through SSU × rpm = 1.35×10^6. Following this line to left and upward to intersection with viscosity = 1000 SSU, best pump speed is seen to be 135 rpm. If 1000 rpm, 600 psi, and 1000 SSU are investigated, corresponding over-all efficiency is 47%, volumetric 98%. This is a decrease in over-all efficiency of 29% due to increase in speed and consequent increase in viscous drag. Cost of installing pump large enough to give required delivery at 135 rpm might offset the gain in efficiency. Compromise is intermediate speed of 600 rpm with 60% over-all efficiency.

VANE PUMPS



PISTON PUMPS





USING THE EFFICIENCY CHARTS to plot comparative performance of gear, vane, and piston pumps is easy—just follow lines on chart and read answers directly. These examples are for 1800-rpm pumps, but other speeds are evaluated just as readily. Over-all efficiency will reach peak value at a different pressure for each speed.

path dimensions, and each pump must be tested separately to determine slip and volumetric efficiency. A convenient pump-slip equation, based on flat-plate flow, is: $Q_s = (C_s D) \times (\Delta P/\mu)$, where C_s and D depend on effective width-length-clearance relationship and pump size.

Note that slip is a function of pressure, not speed. Doubling speed does not double slip—slip flow stays the same, so long as discharge pressure does not change. Percent slip—slip per gpm delivered—actually becomes one-half original value, because delivery flow doubles with speed. Also note that doubling viscosity halves slip.

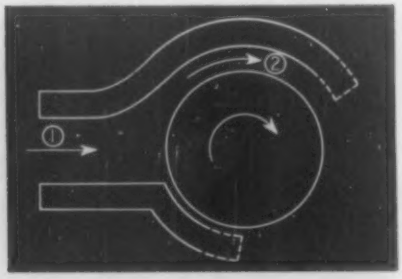
Slip limits the maximum pressure of a positive-displacement pump. Assuming no cavitation, delivery flow $Q_d = DN - Q_s = DN - C_s D\Delta P/\mu$. Rearranging terms, pressure rise $\Delta P = \mu(DN - Q_d)/(C_s D)$. The maximum pressure (developed when $Q_d = 0$) is $\mu N/C_s$.

All these effects—slip, friction, viscosity, speed and pressure—have been taken into account in the "averaged" efficiency charts. But individual pumps vary in design and workmanship.

SUCTION-HEAD CHART

For each condition of flow and speed there is a minimum value of inlet total pressure (static plus velocity head) that will prevent cavitation. This minimum inlet head, based on P_v as the datum, is known as required net positive suction head (NPSH) and depends on: viscosity of liquid, square of velocity (V^2) of the pumping element, vapor pressure of liquid, design of inlet flow path, smoothness of pumping cycle, and percentage of dissolved air. Experience shows these combined effects tend to vary mostly with V^2. The simplified suction-pressure chart is based on V^2 and is fairly accurate for all positive-displacement pumps handling moderate liquid viscosities (up to 200 SSU).

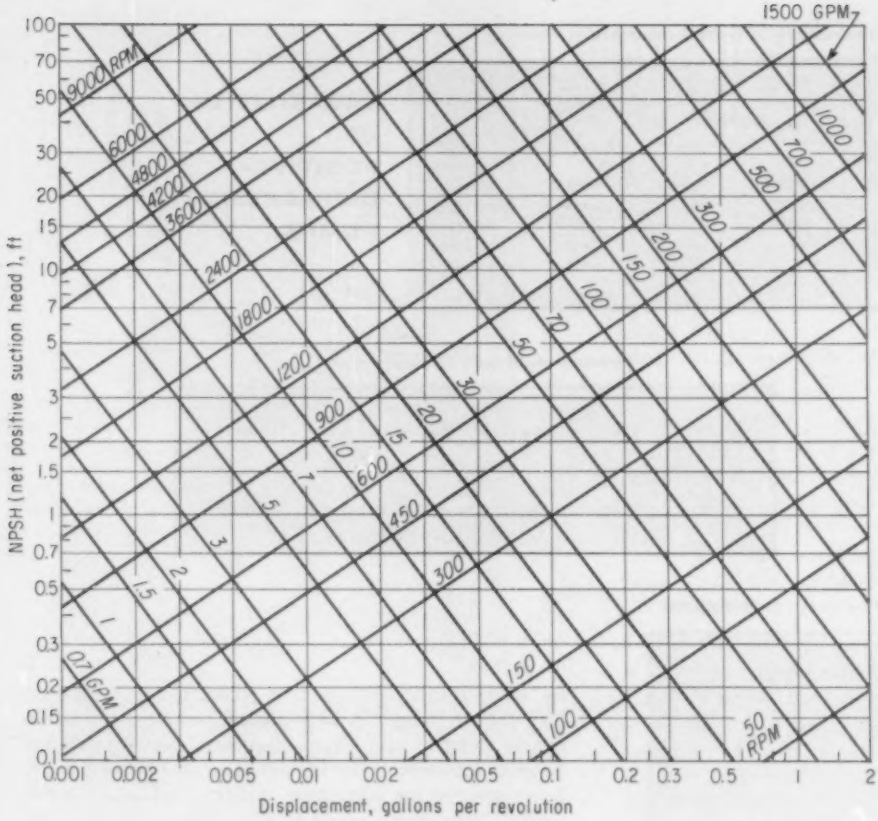
To avoid cavitation, available NPSH must be greater than required NPSH. For example, if the liquid (sketch, this page) reaches the pump inlet with zero velocity and is at a pressure equal to or less than its vapor pressure, it cannot be forced into the pump. The same is true if its total inlet pressure (velocity head plus static head) is less than that of fluid adjacent to moving pump element. Here is why (see sketch):



Liquid at point 1 must enter pumping chamber at point 2. Between 1 and 2 there may be gear teeth, vanes, rotor, piston, or other pump elements. At point 1 the liquid has velocity V_1 and pressure P_1. Energy (total head) per unit mass available to move liquid into pump is sum of its kinetic energy $V^2/2g$ and pressure (or potential) energy $P_1/\rho g + Z$, minus its vapor-pressure head $P_v/2\rho g$. Thus available NPSH $= V_1^2/2g + (P_1 - P_v)/\rho g + Z$.

If there were no losses of energy between points 1 and 2 and velocity V_1 was exactly equal to the required velocity V_2 at point 2, liquid would flow readily into pumping chamber even when $P_1 = P_v$. In practice, many pumps have considerable loss in energy between 1 and 2—while others actually add energy to liquid in inlet region by shearing action and other means. The required NPSH $= V_2^2/2g + H_L - H_a + P_v/\rho g$, where H_L is head loss, H_a is gain.

Available NPSH for piston pumps varies during each suction stroke, because flow pulses somewhat, depending on design. At start of stroke, fluid is at rest (or has a relatively low velocity) and available NPSH is reduced by the head needed to accelerate the fluid. At end of stroke, no acceleration is required, and available head depends on friction losses in inlet piping and passages. If inlet piping has an unusual number of fittings, the end-of-stroke (high-friction) condition is important in deter-



NET POSITIVE SUCTION HEAD here is based on square of velocity of pumping element, although other factors strongly influence suction requirements (see text). An example: a given pump has 10-gpm flow, runs at 1800 rpm (it can be gear, vane or piston type—the basic rules still apply.) What is NPSH? Answer: 5.2 ft of liquid pumped, absolute pressure.

mining the NPSH available. The suction-head chart, however, is based on V^2 of pumping element—the more usual criterion.

PUMP PULSATION

Freedom from pulsation—often a primary requirement—depends on geometric (shape), kinematic (velocity and flow path) and dynamic (pressure and force) considerations.

Little can be predicted about the pulsation problem in selecting a pump. Where the problem might be serious, choose a pump with very small slip (very high volumetric efficiency.) This is a good indication of fine workmanship and uniformity of clearances.

Reciprocating pumps inherently have periodic impulses. However, multipiston pumps reduce the magnitude of these variations. Gear, vane, and other positive-displacement pumps have somewhat less pulsation. Theoretically, pumps can be built which eliminate the kinematic and geometric factors contributing to pulsation, but basic design and construction problems prevent elimination of pulsation completely.

Pulsation, although appearing as a fluctuation in pressure, actually arises as a fluctuation in flow rate because pressure is a dependent quantity. Here is why:

Discharge Q_s of a positive-displacement pump $= DN - C_s\Delta PD/\mu$. The system into which liquid is pumped will have some resistance R, where $R = \Delta P/Q_s$ or $Q_s = \Delta P/R$. (This is analogous to Ohm's electrical law, $I = E/R$.)

Equating, $Q_s = \Delta P/R = DN - C_s\Delta PD/\mu$. Noting that $\Delta P = P_{out} - P_{in}$, it can be shown that this relationship between pressure, flow, and discharge resistance applies:

$$P_{out} = (DN)/(1/R + C_s D/\mu) + P_{in}$$

If N, R, C_s and P_{in} remain constant, the discharge pressure will be constant. But C_s depends on cube of pump internal clearances, and can vary during each revolution, thus introducing large flow fluctuations. Flow and pressure fluctuations are directly related: $\Delta(P_{out})/P_{out} = \Delta(Q_s)/Q_s$, where Δ indicates a small change.

EXAMPLES OF PUMP SELECTION

1—Liquid Transfer

REQUIRED: to pump 50 gpm of 100-SSU oil (70 F) to pressure of 250 psi. Motor drive will be at 1800 rpm. Inlet conditions are good, and available pressure is at least 13 psi.

SOLUTION: A large number of suitable pumps are available; however, piston pumps are somewhat expensive, and the low-pressure service does not justify them. A lower cost turbine pump can also perform in this range, but has low efficiency—less than 50%. Vane, gear or lobe pumps seem indicated.

Power-output nomograph shows that output hp is 7.2. Assuming over-all efficiency of 70%, which is reasonable

Relative desirability of typical commercial types

Pressure	Flow	Speed	hp/lb	Cavitation	Cost
piston	lobe	gear	vane	vane	gear
gear	screw	vane	gear	screw	vane
vane	gear	piston	piston	lobe	lobe
screw	vane	lobe	lobe	gear	piston
lobe	piston	screw	screw	piston	screw

CAPABILITIES OF POSITIVE-DISPLACEMENT PUMPS

Power-weight ratio (typical values)

Type	vane	gear	piston	lobe	screw
hp/lb	0.26	0.11	0.09	0.02	0.01

For the final specification—Data needed by pump manufacturer

Pressure	inlet, differential, discharge, line-and-fitting losses
Flow	gpm
Speed	rpm (range and max)
Liquid	viscosity, specific gravity, chemical inertness, operating temperature, cleanliness (solids? abrasives?)
Piping	suction conditions (flooded? lift? self-prime?)
Duty	continuous, intermittent, hours per day, days per year, driving motor, dust, moisture, fire hazard, corrosive fumes.
Misc.	seals desired, pump materials recommended, mounting.

for either a vane, gear, or lobe pump, the motor should have at least 10 hp. (A 50%-efficient turbine pump would require about 15 hp.) Gear pump would perform well and be quite economical. Its life would be long because liquid being pumped has lubricating qualities, and service is not severe. Vane pump would be somewhat more expensive, have slightly higher efficiency, and perform well. If efficiency is not the primary need, choose a gear pump.

2—High Lift

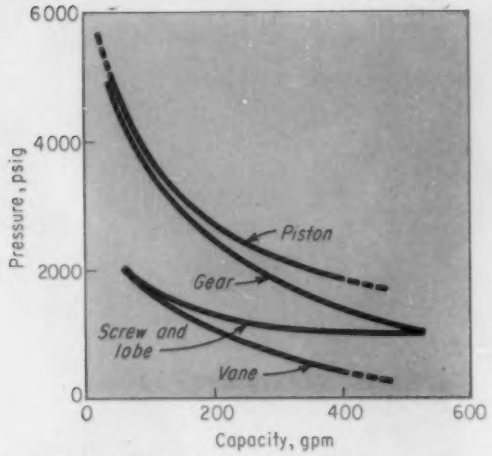
REQUIRED: transfer of viscous liquid from submerged tank 18 ft deep (lowest depth is 18 ft, but surface is essentially at ground level). Pump is to be placed at ground level. Vapor pressure of liquid at ordi-

contributing manufacturers

This article was prepared by Dr Wilson at the request of PRODUCT ENGINEERING to meet the industry's need for a quick, consistent pump-selection method.

In writing the article, Dr Wilson had the cooperation of the following manufacturers:

Adel Precision Products; American Engineering Co; Aurora Pump Div of New York Air Brake Co; Berry Hydraulics Div of Oliver Tyrone Corp; Bendix Aviation Corp, Lakeshore Div and Hamilton Div; Bijur Lubricating Corp; Blackmer Pump Co; Cessna Aircraft, Industrial Products Div; Commercial Shearing and Stamping Co; The Cornelius Co; Crossley Machine Co; Curtis-Wright Corp, Marquette Div; DeLaval Steam Turbine Co; The Deming Co; Denison Engineering Div, American Brake Shoe Co; Double A Products Co, subsidiary of Brown and Sharpe Mfg Co; Dynex Inc; Eastern Industries Inc; Eco Engineering Co; Hartmann Mfg Co; Hupp Aviation Co; Hydraulic Accessories Co; Hydraulic Products Div of Clark Equipment Co; Hydreco Div and Kinney Mfg Div of New York Air Brake Co; Jabsco Pump Co; John S Barnes Corp; Kellogg Div of American Brake Shoe Co; Lord Mfg Co; Manton-Gaulin Mfg Co Inc; Mechanisms Inc; Milton Roy Co; Moyno Pump Div, Robbins & Myers Inc; Northern Ordnance Inc, subsidiary of Northern Pump Co; Oberdorfer Foundries Inc; Oil-Dyne Inc; The Oilgear Co; Owatonna Tool Co; Parker Hydraulic Div of Parker-Hannifin Corp; Pesco Product Div of Borg-Warner Corp; Racine Hydraulics & Machinery Inc; Rockwell Mfg Co; Roper Hydraulics & Machinery Inc; Schutte & Koerting Co; SC Hydraulic Engineering Co; Sier-Bath Gear and Pump Co Inc; Simplex Engineering Co; Sundstrand Corp; Thompson Products Inc; Transfer Pump Co; Turbocraft Inc; Tuthill Pump Co; Vanton Pump and Equipment Corp; Vickers Inc; Viking Pump Co; Waldorf Instrument Co; Waterous Co; The Wayne Pump Co; Webster Electric Co, Oil Hydraulics Div; and Worthington Corp.



MAXIMUM PRESSURE AND FLOW values plotted here are from typical manufacturers catalogs. However, higher ratings are sometimes available for special applications.

nary temperatures is 2 psia. Flow is 150 gpm; discharge, 550 psi; viscosity, 1000 SSU at 70 F. Motors with speeds of 1800 or 2700 rpm are readily available; slower speeds will cost more.

SOLUTION: Gear, vane and piston pumps are available, but suction-head nomograph indicates that NPSH required is 32 ft of water. With an actual viscosity of 1000 SSU and an available NPSH of something in the order of 10 ft of liquid with a pump operating at 1800 or 2700 rpm, no pump is adequate. The manufacturer should be consulted, because cavitation problem is serious. There will be little competition on an economic basis—only a few pumps are available and none operate at speeds of 1800 or 2700 rpm. However, a pump with a displacement of 0.25 gal. per revolution running at 600 rpm could handle the situation.

3—Hydraulic Control Pump

REQUIRED: 1500 psi, 25 gpm, viscosity 150 SSU at 100 F. Motor to run at 1800 rpm. There are no problems regarding inlet pressure.

SOLUTION: Three types—gear, vane and piston—are available. Therefore selection must be based on some special characteristic or on costs. If pulsation is a serious problem, a piston pump with its periodic-flow characteristic might not be suitable; but a well-designed vane or gear pump will have smooth flow free from pulsation.

4—Fluid Power

REQUIRED: flow of 50 gpm at 4500 psi.

SOLUTION: Only piston and gear pumps are available—and very few manufacturers are producing pumps for this service. However, inlet conditions are good, viscosity of oil is 150 SSU at 100 F, and motor runs at 1800 rpm. Gear pump is cheaper, is less likely to cavitate. But efficiency is higher for the piston type. Either pump meets the requirements.

5—High Altitude

REQUIRED: to pump fuel at 3600 rpm, with flow of 100 gpm at 750 psi, viscosity 30 SSU. Pressure available at inlet is 3.5 inches of mercury absolute and vapor pressure is 2 inches. Many pumps will deliver 100 gpm at 750 psi, but no standard pump will deliver satisfactorily under inlet conditions prescribed.

SOLUTION: Specially designed pump, free from civitation even though energy available at inlet is extremely small. Any significant drop in pressure between the inlet and the pumping element is intolerable because vapor pockets would form and cause serious cavitation.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, NY.

EDITOR'S NOTE: These previous PE articles give details on the basic pump types. Dr Wilson's name appears in parenthesis after titles of previous articles he authored for PRODUCT ENGINEERING.

Hydraulic Pumps, July '55, p 132, covers gear, vane and piston pumps, discussing performance, cavitation, viscosity, volumetric efficiency and noise.

Design Analysis of Rotary Pumps (Wilson), Feb '46, p 138, uses vane pump as example to develop a method for proportioning parts and clearances of rotary pumps to give optimum efficiency for chosen ranges of speed, pressure and viscosity.

Spur-gear Rotary-pump Design, Jan '51, p 101 and Mar '51, p 129, gives mechanical-design method for simple gear pumps.

Centrifugal Pump Selection, Mid-Oct '57, p J-17, gives suction-lift curves and compares performance for various conditions of viscosity, contamination flow and pressure.

Non-clogging Centrifugal Pumps, Nov 10 '58, p 79, describes Swedish-designed pump that has good suction characteristics and will not clog easily when the liquid is viscous or pulpy.

Analysis of Turbine Pumps (Wilson), Oct '47, p 163, describes the theory of this "peripheral" type, and plots typical performance.

Liquid Proportioning by Volumetric Devices, Mid-Oct '56, p J-2, describes many pumps and similar devices that meter and feed.

Thirteen Rotary-pump Mechanisms, June '57, p 180, includes pivoted-vane, disk, gear, roots, and screw pumps.

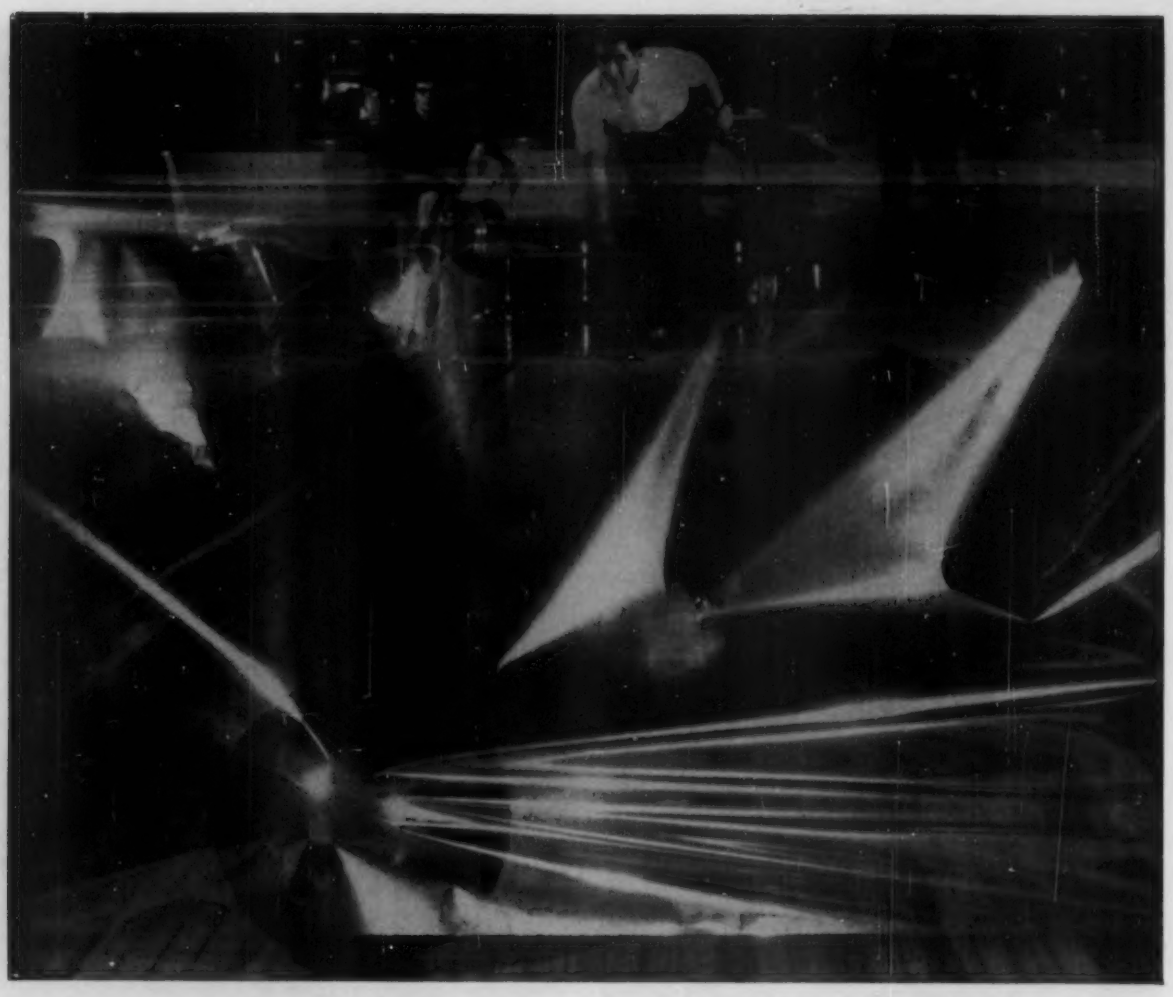
Pump and pumping-system designs are aided by these background articles that cover special problems:

Optimum Clearances in Pumps and Hydraulic Motors (Wilson), Mid-Oct '55, p J-16, develops the theory of flat-plate flow and relates speed, slip, drag and efficiency in gear, vane, and piston pumps.

Cavitation in Positive-displacement Pumps (Wilson), Mar 2 '59, p 47, gives unusual short-cut method for estimating net positive suction head of gear, vane and piston pumps.

Method of Evaluating Test Data (Wilson), Oct '45, p 653, develops some of the equations and methods used in plotting graphs in the article in this issue.

Hydraulic Noise Reduction: By Piston-Pump Modification, Feb '52, p 178; by Fluid Conditioning, Apr '52, p 182; and by Capacitative Load Chamber, Mar '52, p 135, discuss in detail the effects of piston design, air entrainment, and total line volume on cavitation and noise.



MYLAR® has a tensile strength of 20,000 psi

Can the unique combination of properties found in "Mylar" help you solve your design problems?

Tough, thin "Mylar" helps cut cable costs! Because "Mylar" is tough even in thin gauges, cable manufacturers can cut size, weight and manufacturing costs.

"Mylar"* polyester film is a tough, flexible engineering material. In addition to its average tensile strength of 20,000 psi, "Mylar" has excellent resistance to most chemicals and moisture, a dielectric strength of 4,000 volts per mil for 1 mil film, and can withstand temperature extremes from -60° to 150°C.

On an area basis, tough, thin "Mylar" often *costs less* than heavier, conventional materials. "Mylar" can be laminated, embossed and metalized, punched or coated. The film won't become embrittled with age. "Mylar" is available in roll or sheet form in a wide range of gauges.

Find out how the *combination of properties* in "Mylar" can help you solve knotty design problems, improve product performance or cut costs. Write today for our new booklet containing detailed information on properties and applications. E. I. du Pont de Nemours & Co., (Inc.), Film Dept., Room P-9, Wilmington 98, Delaware.

*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

DU PONT **MYLAR®** POLYESTER FILM

USE REINFORCING RINGS on PRESSURE CYLINDERS– but know their effects on stresses

ROBERT I ISAKOWER, *Ordnance Engineer*
Picatinny Arsenal

Reinforcing rings increase structural stiffness of pressure cylinders, prevent buckling when such cylinders are column-loaded, and provide points of support or attachment. But while hoop stresses in the cylinder are reduced, axial stresses are raised. The formulas below give fast, accurate values for pressure-cylinder stresses at the rings and between the rings. Much of the drudgery reduces to simply looking up the factors in the tables.

Symbols

A	= Cross-sectional area of reinforcing ring, in.^{2}
E_c	= Young's modulus for cylinder, psi
E_r	= Young's modulus for reinforcing rings, psi
$2F$	= Contact force between ring and cylinder per circumferential inch, lb/in.
L	= Ring spacing, in.
K	= R/t
P	= Pressure, psi
$Q_{1,2,3,4}$	= Damping factors
R	= Mean radius of cylinder, in.
r	= Mean radius of ring, in.
t	= Thickness of cylinder, in.
x	= Width of ring, in.
y	= Thickness of ring, in.
β	= Flexural damping characteristic
μ	= Poisson's ratio
σ_θ	= Hoop stress, psi
σ_a	= Axial stress, psi
$\phi_{1,2}$	= Material property factors

Assumptions

1. R/t is greater than 10.
2. Reinforcing-ring width is less than cylinder thickness.
3. Values are calculated for a section remote from end closure or discontinuity of contour, loading or material.
4. Reinforcing-ring cross-section is compact.

$$\frac{x}{3} \leq y \leq 3x$$

5. Rings can be either outside or inside.
6. Pressure can be external or internal. When pressure is external, substitute $-P$ for P in the equation.

Formulas

Contact force between ring and cylinder, lb/in.

$$2F = \frac{PRK\,(1 - \mu/2)}{\frac{r^2}{A}\left(\frac{E_c}{E_r}\right) + \frac{K^{3/2}\,\phi_2 Q_2}{2}}$$

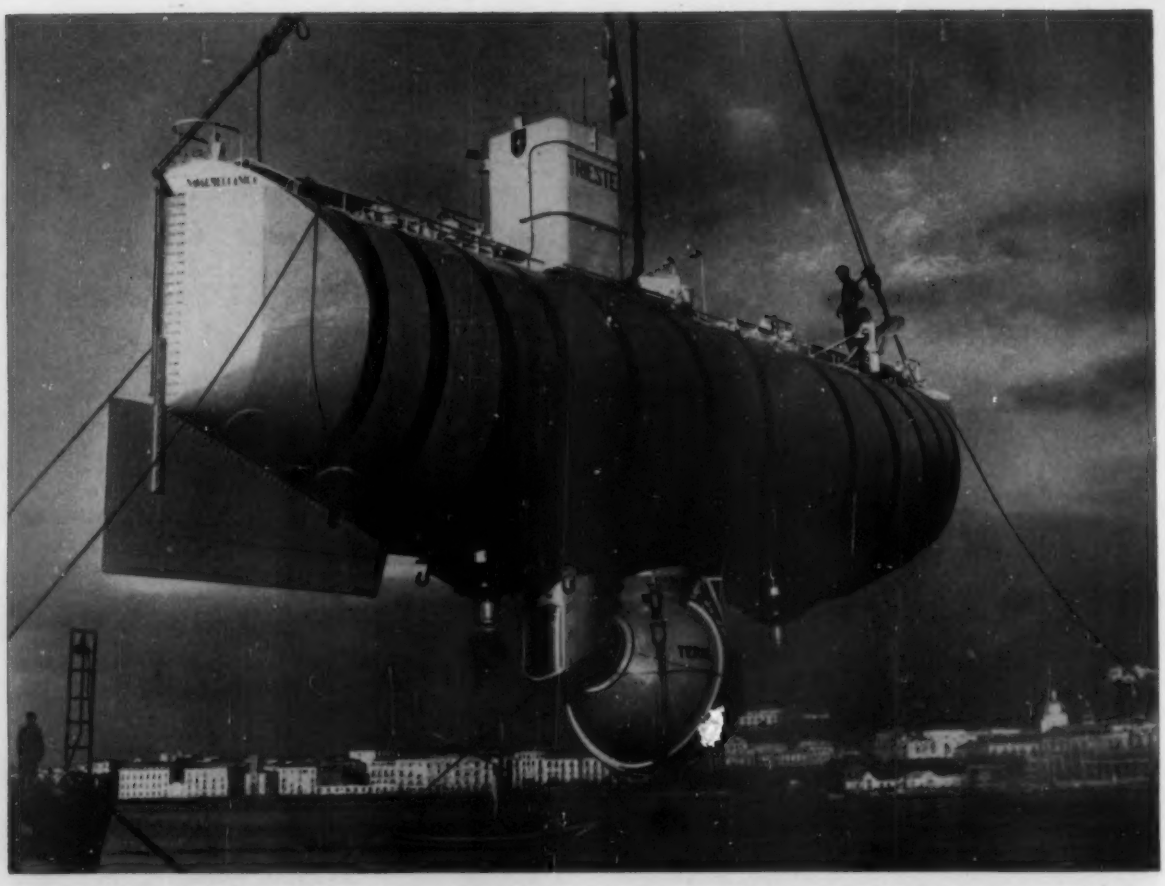
Hoop stress in ring $\sigma_\theta = 2Fr/A$

Cylinder stresses at location m

$$\text{Axial } \sigma_a = \frac{PK}{2} \pm \frac{F\,\phi_1 Q_1 K^{1/2}}{t}$$

$$\text{Hoop } \sigma_\theta = PK - \frac{FK^{1/2}}{t}\,[\phi_2 Q_2 \mp \mu\,\phi_1 Q_1]$$

continued on page 55



Bathyscaph "Trieste", looking like something straight out of Jules Verne, has already made more than 50 scientific voyages to the ocean depths. High-strength nickel-chromium-molybdenum steel protects occupants of spherical cabin from underwater pressures up to 1100 atmospheres, or more than 16,000 pounds per square inch.

Built to explore an unknown world

How nickel alloy steel guards explorers against the crushing pressures of ocean depths

The bathyscaph, a deep-sea vessel, was invented by the Swiss professor, Auguste Piccard, who in the past years has built two: the first one was FNRS 2; its steel cabin is now used by the French Navy (FNRS 3). The other one is "Trieste", now property of the U. S. Navy.

"Trieste" has been down 65 times and recently set a new world's record by descending 35,805 feet below the surface of the Pacific Ocean.

At these depths, water pressure would crush a conventional submarine. But the bathyscaph is not so vulnerable...

Its cabin, hanging under the ship's hull like a giant bubble, is specially designed, using high strength nickel-chromium-molybdenum steel three and a half inches thick. This steel bubble, weighing eleven tons and nearly seven feet in diameter, is large enough to hold two men in comfort – *and safety*.

Problems solved. In perfecting the bathyscaph, its designers naturally ran into many problems. But one by one they overcame their difficulties. And quite often it was with the help of Nickel...

This is especially true of the Nickel which is part of the nickel-chromium-molybdenum steel of the cabin. They have Nickel, too, in the stainless steel of vital instruments, among them those in the ballast releasing system. And they also use Nickel in electrical resistances which operate as thermometers for water temperature.

A metal of many uses. Either alone or with other elements, Nickel improves hundreds of alloys, making possible almost any desired combination of properties for meeting specific fabricating or service demands.

Do you have a metal problem? One that involves corrosion... stress... fatigue... high or low temperatures or some other troublesome factor? A nickel-containing material may provide *your* answer.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N.Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

REINFORCING RINGS continued

Cylinder stresses at location n

$$\text{Axial } \sigma_z = \frac{PK}{2} \pm \frac{F\,\phi_1 Q_3 K^{1/2}}{t}$$

$$\text{Hoop } \sigma_\theta = PK - \frac{FK^{1/2}}{t}[\phi_2 Q_4 \mp \mu\,\phi_1 Q_3]$$

EXAMPLE:

Find the effect on stresses in a steel pressure vessel from adding reinforcing rings.

$E_c = E_r = 30 \times 10^6$ psi
$P = 8000$ psi
$R = 10$ in.
$t = 1.0$ in.
$\mu = 0.30$

Before adding rings, the cylinder stresses at a point not near the end closures are:

$$\text{Axial } \sigma_z = \frac{PR}{2t} = \frac{PK}{2} = \frac{8000 \times 10}{2} = 40{,}000 \text{ psi}$$

$$\text{Hoop } \sigma_\theta = \frac{PR}{t} = PK = 8000 \times 10 = 80{,}000 \text{ psi}$$

After adding rings

$L = 5$ in.
$r = 11$ in.
$x = 1.0$ in.
$y = 1.0$ in.

$$\beta = \frac{[3(1-\mu^2)]^{\frac{1}{4}}}{\sqrt{Rt}} = \frac{[3(1-0.09)]^{\frac{1}{4}}}{\sqrt{10 \times 1}} = 0.406$$

$\beta L = 0.406 \times 5 = 2.03$

From the tables,

$\phi_1 = 0.3891$ $\quad Q_1 = 3.8472$ $\quad Q_3 = -0.2280$
$\phi_2 = 1.2865$ $\quad Q_2 = 1.1334$ $\quad Q_4 = 1.012$

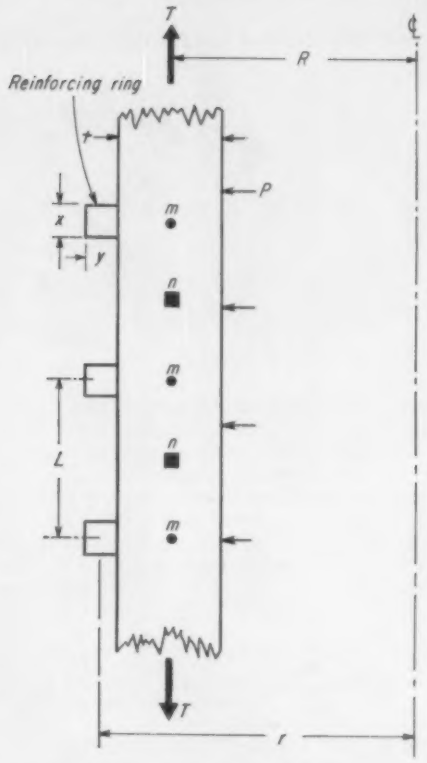
$$2F = \frac{8000 \times 10 \times 10\,(1 - 0.30/2)}{\frac{121}{1} \times 1 + \frac{31.6 \times 1.2865 \times 1.1334}{2}}$$

$= 4720$ lb/in.

Cylinder stresses at position m

$$\text{Axial } \sigma_z = \frac{8000 \times 10}{2} \pm \frac{2360 \times 0.3891 \times 3.8472 \times 3.16}{1}$$

$= 40{,}000 \pm 11{,}150$
$= 51{,}150$ psi max



$$\text{Hoop } \sigma_\theta = 8000 \times 10 - \frac{2360 \times 3.16}{1}[1.2865 \times 1.1334 - 0.30 \times 0.3891 \times 3.8472]$$

$= 72{,}540$ psi max

Hoop stress in ring

$$\sigma_\theta = \frac{2 \times 2360 \times 11}{1} = 51{,}900 \text{ psi}$$

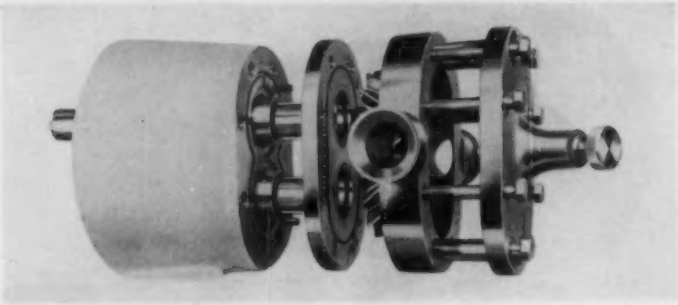
Table I—Material-property Factors

μ	$1-\mu/2$	ϕ_1	ϕ_2
0.25	0.875	0.3861	1.2950
0.30	0.850	0.3891	1.2865
0.35	0.825	0.3925	1.2737
0.40	0.800	0.3968	1.2600
0.45	0.775	0.4020	1.2436

Table II—Damping Factors

βL	Q_1	Q_2	Q_3	Q_4
0.0	18.0000	3.0000	2.0000	0.0000
0.2	13.6776	2.9302	1.6200	1.9814
0.4	10.2768	2.7568	1.2796	1.9302
0.6	7.7172	2.5256	0.9776	1.8534
0.8	5.8884	2.2708	0.7128	1.7568
1.0	4.6704	2.0166	0.4830	1.6462
1.2	3.9408	1.7798	0.2862	1.5256
1.4	3.5868	1.5698	0.1198	1.3994
1.6	3.5088	1.3918	−0.0186	1.2708
1.8	3.6180	1.2468	−0.1314	1.1424
2.0	3.8472	1.1334	−0.2216	1.0166
2.2	4.1424	1.0488	−0.2914	0.8952
2.4	4.4628	0.9888	−0.3432	0.7798
2.6	4.7772	0.9492	−0.3794	0.6710
2.8	5.0676	0.9262	−0.4022	0.5698
3.0	5.3244	0.9154	−0.4136	0.4768
3.5	5.7876	0.9222	−0.4032	0.3910
4.0	6.0228	0.9484	−0.3588	0.1334
4.5	6.1020	0.9736	−0.2964	0.0324
5.0	6.0960	0.9908	−0.2298	−0.0332

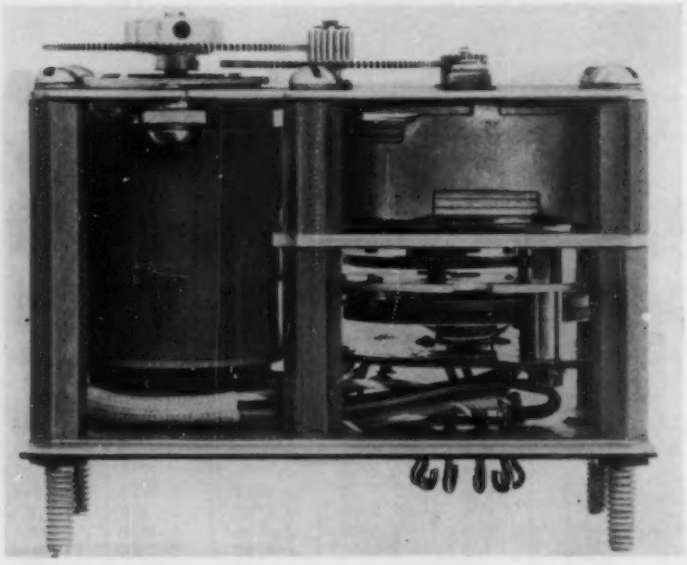
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Stainless steel high-pressure pump . . .

is available in two sizes, which cover capacity range from 1 to 30 gpm, pressures to 400 psi, temperatures to 180 F or higher with special seal materials. Pump has true involute, double-helical gears that run in contact with each other; solid Teflon lubricant inserts in pump gears, quick-change quad ring seals, and sealed-off relief valve that uses bell washers for accurate pressure control. Prices for basic pump units are $700 for smaller pump; $950 for larger pump. Delivery, 6 to 8 wk. **Sonic Engineering Corp, 146 Selleck St, Stamford, Conn.**

Circle 300 on Reader Service Card



Magnetic rotary steppers . . .

operate on number of pulses received, not on changes in phase angle or voltage. Stepping action is achieved magnetically, without ratchets, linkages or contacts. Suited for precise angular positioning of rotary components, units may be coupled to synchro transformers or predetermined pulse counters. When coupled to synchro transformer, stepper can be pulsed to rotate through given number of closed-circuit positions, then, on last pulse, complete an open circuit aligned with zero angular reference of transformer. Harnessed to predetermined pulse counters, and corresponding switches, positioning devices can be used to transmit angular information to remote locations. Said to meet or exceed MIL-E-5272C. **A W Haydon Co, 232 N Elm St, Waterbury, Conn.**

Circle 301 on Reader Service Card

Electric heating elements . . .

priced at one-third to one-fifth of former prices for silicone-rubber heating elements are offered in 1-in. widths and over-all lengths of 1½ to 12 in. Thickness is 0.12 in. or less. Resistance per unit of length can be from 1.27 to 1800 ohm per in. of heated length. Resistance tolerance is ±7%. Units cemented to metal are said to be able to dissipate up to 25 w/sq in. Available with lugs or leads. Reported to withstand continuous operation at temperatures in excess of 450 F. Base price is 33¢ with lugs and 42¢ with leads, plus 7½¢ per in. of over-all length for 100 units or more. Delivery, 1 to 2 wk. **Electro-Flex Heat Inc, 83 Woodbine St, Hartford 6, Conn.**

Circle 302 on Reader Service Card

Viscoelastic damping compound

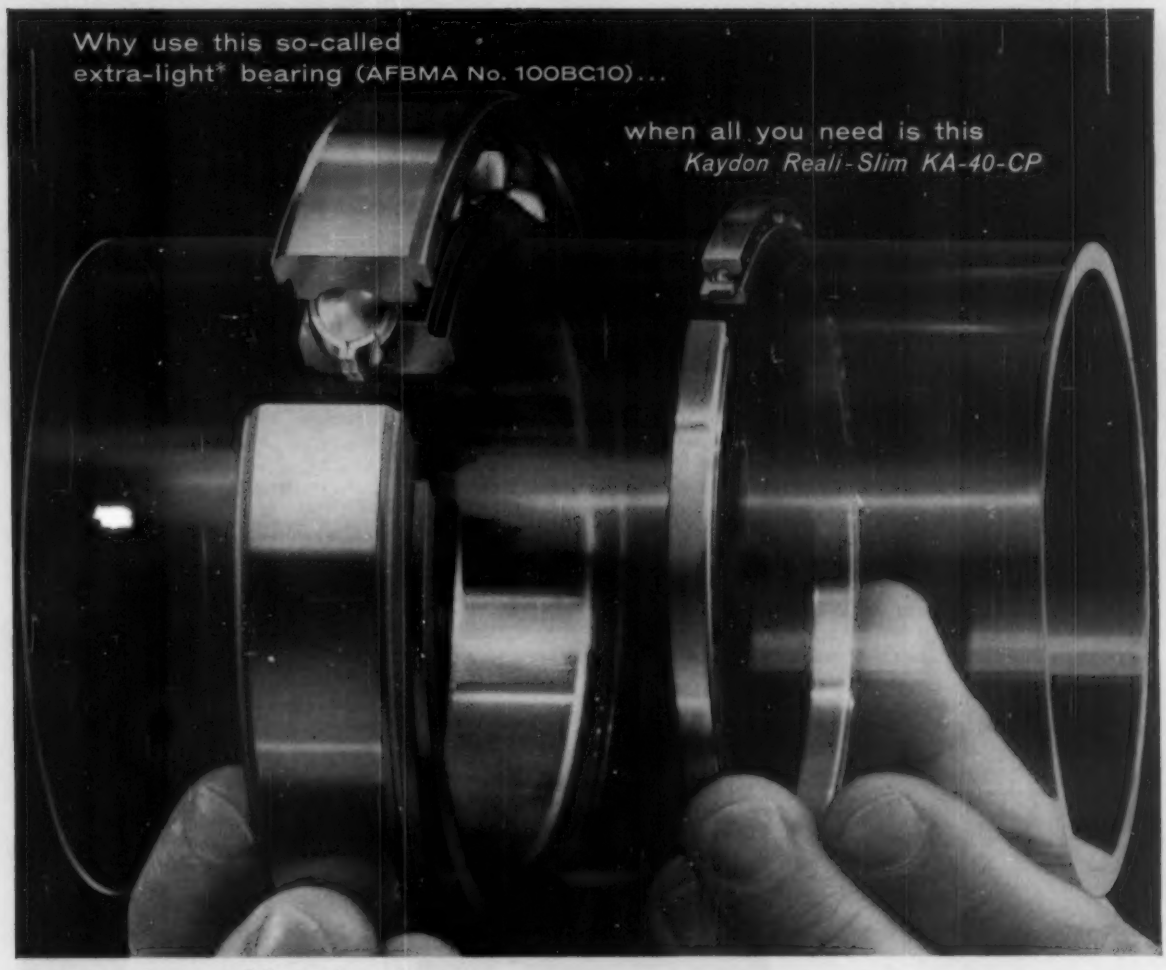
is reported to reduce structurally borne noise and vibration when sprayed or trowelled onto metal plate. Compound renders metal plate almost equivalent to critically damped structure, as exhibited by low-resonant magnification under vibration and imperceptible ringing under shock. Compound dries to smooth finish, is nontoxic and nonflammable. **Korfund Co, 48-78Q 32nd Pl, Long Island City 1, NY.**

Circle 303 on Reader Service Card

Rotary limit switch . . .

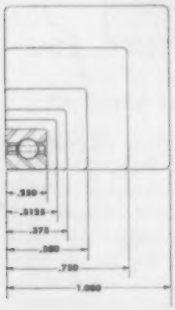
with 10-amp rating weighs less than 0.16 lb. Aircraft-quality unit offers SPDT single or double circuit control or DPDT four-circuit control. Operating lever contains micrometer screw for infinite operating point adjustment. Separate self-locking nut fixes operating point. Lever moves full 360°, continuously if desired. Internal cams are designed for various jobs, such as providing variations in standard 6-degree movement differential, and on-off switch se-

continued on page 58



News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Kaydon's volume production cuts prices as much as 76%, depending on size. Write for free, fact-filled "CP" bearing bulletin — with prices!

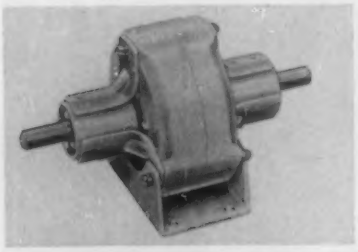
THE KAYDON ENGINEERING CORP.
MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-160

quence. Heart of unit is type 16 subminiature switch, which is said to offer a mechanical life in excess of 20 million cycles and shock and vibration resistance. **Licon Div, Illinois Tool Works, 6606 W Dakin St, Chicago 34.**

Circle 304 on Reader Service Card



Lightweight 10 ft-lb clutch . . .

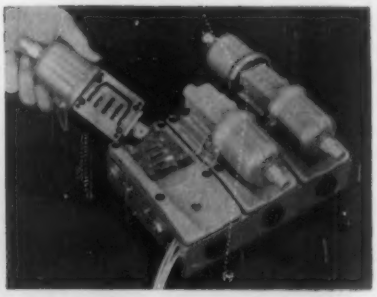
has been reduced about one-third below older version of foot-mounted dry magnetic particle clutch in both weight and price. Said to be totally improved unit, offering faster response and longer life than original unit. Testing on typical application was reported to have been discontinued when test goal of 10 million high-inertia accelerating cycles was reached. **Vickers Inc, Electric Products Div, 1815 Locust St, St Louis 3.**

Circle 305 on Reader Service Card

Three-way 10,000-psi valve . . .

is for remote control of hydraulic units having spring, manual or gravity ram return. Control handle moves to three positions—ram advance, hold and ram return. In hold position, ram pressure is maintained while pump is operating. Valve block has three ⅜-in. NPT pipe outlets, including one for high-pressure takeoff and two for high- and low-pressure takeoff from the pump. **Greenlee Tool Co, Rockford, Ill.**

Circle 306 on Reader Service Card



Solenoid-operated air valves

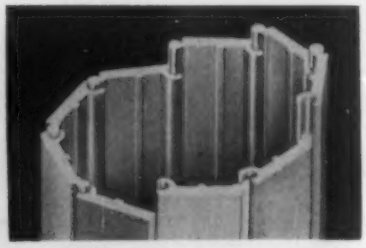
can be ganged, two to ten or more units, to form common-inlet, common-exhaust and common-conduit channels. If more than one pressure is to be used, valves can be isolated and pressure fed from each end of manifold. First model in new ¼-in. series is four-way valve. Every manifold has bottom and side ports with suitable plugs, permitting use either way. Single-solenoid model is $55; double-solenoid unit is $70. Delivery from stock. **Machanical Air Controls Inc, 10030 Capital Ave, Detroit 37, Mich.**

Circle 307 on Reader Service Card

One-component adhesive . . .

is high-strength, modified epoxy-resin material that provides unlimited working life for bonding high-volume metal and plastic structural assemblies. Contains latent hardener that eliminates weighing and mixing hardener with base resin at time of use. Said to provide metal-to-metal bonds with shear strengths of 2500 at 75 F, to maintain high strength over temperatures of —67 to 300 F, to exceed requirements of MIL-A-5090B Class A and MIL-A-8431 Type 1, and to be self-filleting. Only contact pressure is required during curing. Optimum cure is 60 min. at 300 F. May be applied by knife coating, spatula, notched trowel or flowing into place. **Adhesives, Coatings and Sealers Div, Minnesota Mining and Mfg Co, 900 Bush Ave, St Paul 6.**

Circle 308 on Reader Service Card



Magnesium interlocking units . . .

are extruded to close tolerances in variety of shapes and sizes to suit application. **White Metal Rolling & Stamping Corp, 92 Moultrie St, Brooklyn 22, NY.**

Circle 309 on Reader Service Card

High-strength bolts . . .

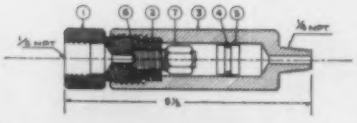
with increased across-flats dimensions that are said to result in greater bearing area, are offered in ½ to 1½ in. dia. By increasing width of hexagon head to same dimensions as nut, it is now possible to torque bolts and nuts with same wrench or socket. Use of bolt is reported to allow tension to be raised from 90 to 100% of min proof load. Min bolt tension, equal to proof load of ASTM specification A-325, ranges from 12,050 psi in ½-in. bolt sizes to 103,950 psi in 1½-in. bolt sizes. Bolts and nuts are impact-formed from controlled analysis carbon steel. Available from stock. **Screw and Bolt Corp of America, Pittsburgh.**

Circle 310 on Reader Service Card

Air-actuated impulse counter

is actuated by impulses of 15 psi minimum. Registers up to 100,000. Threaded T in air line is all it takes to install unit. Standard fitting is ¼-in. pipe thread. Counter is lifetime-lubricated. **Dorsee Mfg Co, 3 Howard St, New York 13.**

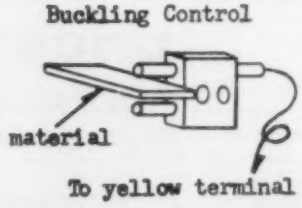
Circle 311 on Reader Service Card



Flow-check snubber . . .

protects against leakage of noxious, toxic or flammable liquids or gases in event of pressure-instrument failure. Isolates instruments from pressure-actuating medium and is said to assure accurate readings from 100 to 5000 psi. Device is reported to respond to small pressure changes within its range, with full equilibrium reached in 2 to 3 sec. Works with instruments actuated by bourdon tubes or diaphragms. **Chemiquip Co, 36 E 10th St, New York 3.**

Circle 312 on Reader Service Card



Additional detection circuits

for protection against buckling, end-of-material and short-feed have been built into missing-parts detector. Visual reset and circuit-checking indication have also been incorporated. Yellow circuit, with associated detection devices, automatically stops machine if circuit is grounded. Used as a buckling detector, material rides between two-tined buckle-control fork; as an end-of-material detector, flag drops and makes ground when material runs out. Red circuit stops machine if there is unintentional break from ground. In use, it acts to protect against damage from short

continue on page 60

MARINE POWER

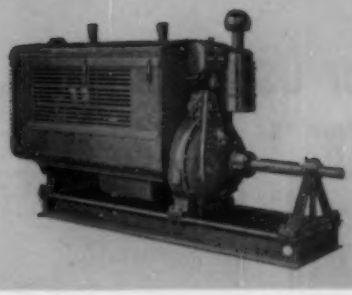
CONSTRUCTION POWER

GROUND SUPPORT POWER

"Our sales have increased over 500% since we began using International engine assemblies five years ago." Report from R. C. Bolling, President, Palmer Engine Co.

"International diesel engines meet our standards for efficiency, dependability and parts and service coverage." Report from Guy Banister, Chief Technical Engineer, Barber-Greene Co.

"The wide range of power in the International line fits in with our plans to offer a wide selection of models." Report from Roger Frantz, Design Engineer, Hobart—Motor Generator Corp.



LEADING ENGINEERS

choose International Power for a wide variety of jobs!

Efficient and dependable power is assured for products of leading engineers, who specify IH engines for a wide variety of applications. Design engineers serve many different industries, but they all have one common problem: to find the most practical, economical and efficient power for their products. If you have the responsibility for selecting the power for your products it will pay you to check International engines because—

FIRST, you have a wide selection of power from which to choose—35 engines from 16.8 to 385 max. hp—available in gasoline, LP gas, natural gas or diesel.

SECOND, IH engines meet rigid requirements of economy and dependability. Millions of hours of continuous operation in all parts of the world have job-tested International power on every heavy-duty application.

THIRD, your customers never have to wait for replacement parts. International's world-wide parts and service facilities back up your organization with fast assistance on power problems.

Check the complete line of IH engines now, and discover the extra selling advantages International power adds to your product. Call or write to International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL®
IH ENGINES

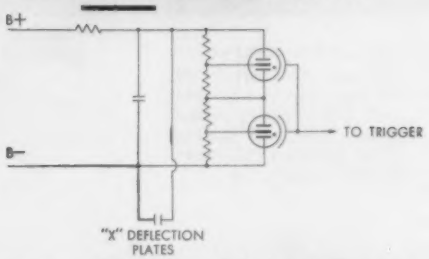
International Harvester Co.,
180 North Michigan Ave., Chicago 1, Ill.
A COMPLETE POWER PACKAGE

CIRCLE 59 ON READER SERVICE CARD

This G-E Glow Lamp

NE-77

in this circuit...



gives this Heyer Oscilloscope

a clean "sweep"

HOW HEYER USES THIS GLOW LAMP. This oscilloscope makes interesting use of General Electric's NE-77—the three-element glow lamp. In their device, a spark plug tester, two NE-77's control the sweep on the scope. However, the circuitry, developed by Heyer Industries, Incorporated, Belleville, New Jersey, does *not* use the center electrode for triggering the lamps. Instead they're triggered by a pulse applied to a metallic shield around the lamps. There are 2 reasons for using the G-E NE-77 instead of other glow lamps: (1) higher holdoff voltage than most neons, and (2) a greater sensitivity to shield pulsing than other neon diodes. This is one example of how a G-E Glow Lamp performs its intended function—and a little bit more. You'll find the same flexibility and dependability in the G-E Glow Lamp you choose for your own circuitry.

How the G-E NE-77 Normally Works. A low current signal applied to the trigger (center electrode) starts the lamp, permitting conductance of peak current surges up to 100 m.a. in the power circuit. It can be used as a control device with photocells, thermostats, moisture sensors, or other low current detectors as trigger elements.

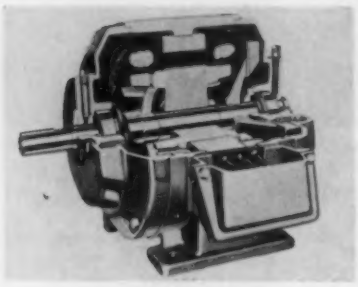
For more information, write for: Specification Sheet #3-092 "G-E Glow Lamps for Circuit Component Use". General Electric Co., Miniature Lamp Dept. M-019, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

feed, by making certain that incoming material reaches certain point by predetermined time. **Wintriss Inc, 20 Vandam St, New York 13.**

Circle 313 on Reader Service Card



Open weatherproof ac motor . . .

with epoxy-encapsulated insulation system is available in frames 180 through 445U (1 through 125 hp) in all standard speeds and voltages. Stator windings are encapsulated in epoxy resin; bearings, exposed internal metal surfaces, hardware and mechanical parts are also said to be protected by a rust-preventing coating against environmental conditions in all types of indoor and outdoor applications. Full Class B insulation system is applied by vacuum-impregnation process. **Reliance Electric and Engineering Co, 24701 Euclid Ave, Cleveland 17.**

Circle 314 on Reader Service Card

Air-control sleeve valve . . .

is three-way, two-position unit that can be installed in any position, on machinery itself or on cylinder to be controlled. Measures 2¾ x 1⅛ in. dia. Eight air-passage holes allow valve to operate close to full capacity with low friction loss. Controls single-acting, spring-return cylinders automatically. Deliveries from stock. Price is $3.75. **Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.**

Circle 315 on Reader Service Card

Transistorized decade counter

is 100-kc add-subtract unit with simple switching control. Available in single-voltage model, requiring 100 v at 40 milliamp; or dual-voltage model requiring 30 v at 35 milliamp and 60 v ac at 1 milliamp. Has ten-number display, electrical zero reset. Size is 3⅛ x 1 x 3¾ in. Weight is 3 oz. For production quantities of 100 or more, counters are $73 and $63, respectively. Delivery, 2 to 4 wk for 1 to 24 units. **Robotomics Inc, 4624 E Garfield, Phoenix, Ariz.**

Circle 316 on Reader Service Card

continued on page 63

Revere helps "fit the metal to the job"

AND A MAKER OF MEDICINE CABINET MIRROR FRAMES SAVES $10,000 A YEAR

As a result of a suggestion made by one of Revere's Technical Advisors, a maker of mirror frames for medicine cabinets has saved $10,000 a year on polishing costs alone. The suggestion was that, by changing to a brass of different grain size, the manufacturer might be able to save money on polishing costs and at the same time improve the quality of his product. (The 90° bend to which the mirror frames are subjected also had to be taken into consideration.)

Samples were made using a Revere Brass Strip with a smaller grain size as recommended by the Technical Advisor. Tests showed that, as a result of the change the manufacturer was able to realize a saving of 17¢ per mirror frame on polishing costs alone, with no increased costs in other operations, including the 90° bend. Based on the saving per frame this manufacturer has saved $10,000 per year for the past 4 years!

Here is still another example of how Revere's Technical Advisory Service working with the customer and the mill helped "fit the metal to the job," thus saving the customer money as well as improving product quality.

Why don't you take advantage of the extensive knowledge of Revere's Technical Advisory Service in "fitting the metal to the job?" It's entirely possible this service can save you money . . . help improve the quality of *your* product.

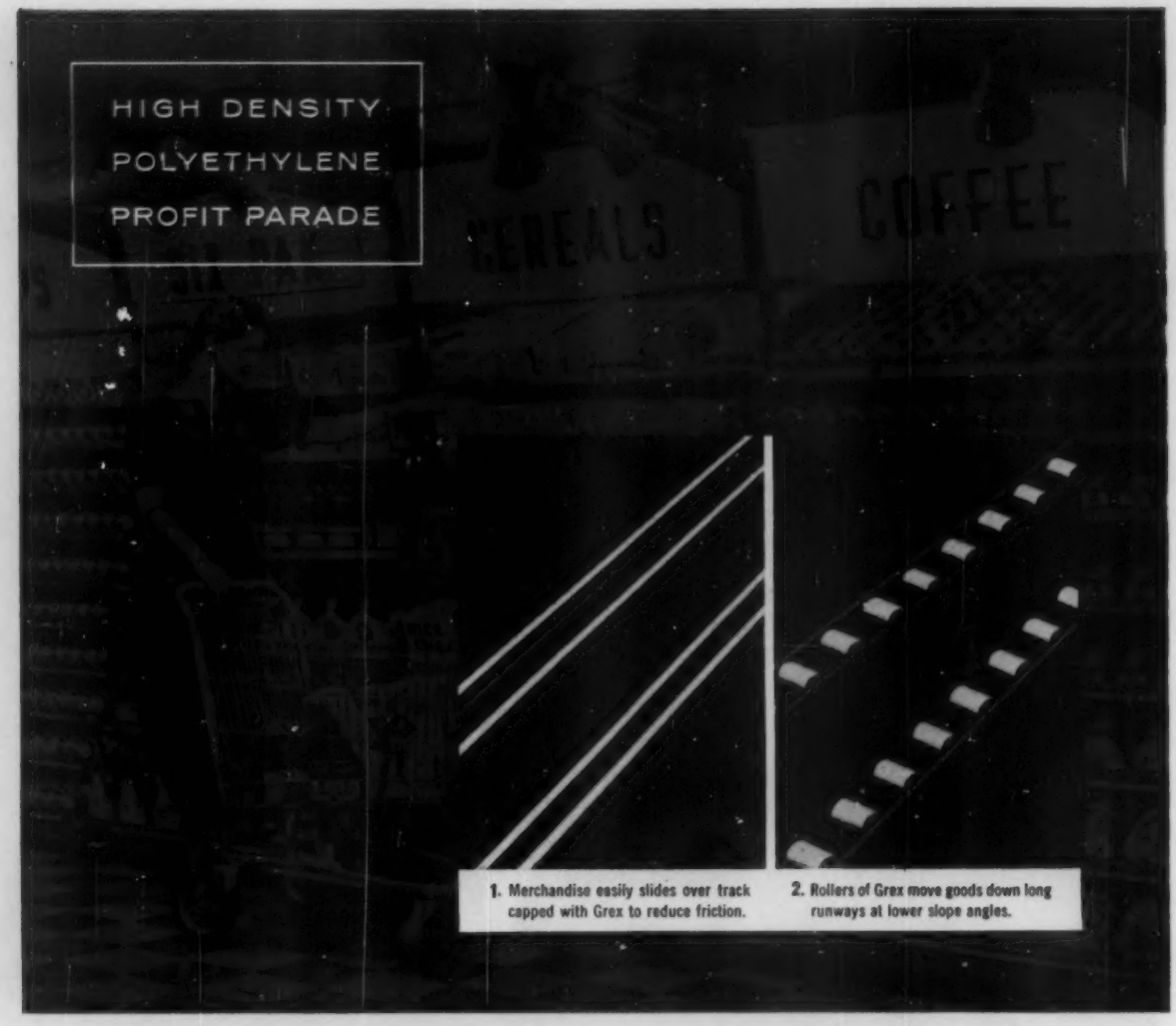
REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices: 230 Park Avenue, New York 17, N. Y.

Mills: Rome, N. Y.; Baltimore, Md.; Chicago, Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Fort Calhoun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

CIRCLE 61 ON READER SERVICE CARD


HIGH DENSITY
POLYETHYLENE
PROFIT PARADE
CEREALS
COFFEE
1. Merchandise easily slides over track capped with Grex to reduce friction.
2. Rollers of Grex move goods down long runways at lower slope angles.

Grace Plastic Solves Friction Problem 2 Ways

North American Equipment Company finds that Grex high density polyethylene is the most practical material available for reducing friction in two types of gravity storage installations. These are utilized in both "Food-O-Mat" for supermarket merchandising and "Quik-Pik" for industrial order picking.

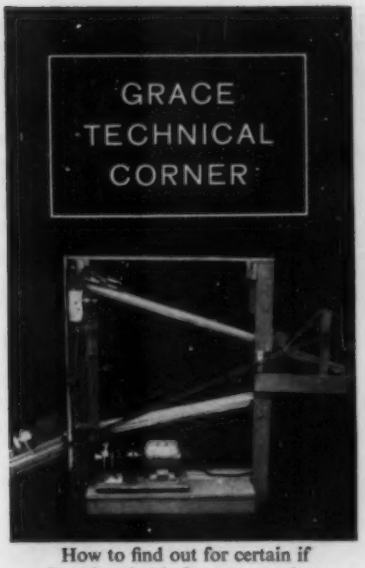
"Quik-Pik" units hold stock which automatically slides down a runway as items are picked from the front. The problem is friction. This friction is overcome in one type of installation by using runways capped with an extruded Grex tubing made by Action Plastics, Inc. Stock slides smoothly over Grex at a slope angle of 12°-14°. The other type of installation moves merchandise at an even lower angle (4°-6°) by utilizing tracks with Grex rollers that never require lubrication and never freeze up. Rollers are made by Gar-Mold, Sefton Div. of Container Corp. of America.

The manufacturer of "Quik-Pik" and "Food-O-Mat" is building a profitable business with superior products that exploit the remarkable properties of Grex. Perhaps you can do the same.

The best way to find out is by calling in the high density polyethylene experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION CLIFTON, NEW JERSEY



How to find out for certain if Grex is suitable for your product.

The rather odd-looking device shown here is a "sliding" machine, invented in the Grace Physical Testing Laboratory. Its purpose was to test the performance of Grex capping for use on metal tracks in "Quik-Pik" installations. Since the tests were highly successful (the manufacturer uses Grex capping at the rate of 2,000,000 feet per year) the machine itself now serves only one function. It testifies that you can expect the same individual help in determining how Grex will work for your product.

Simulates use conditions. Although the Grace laboratories are equipped with every standard physical testing device, it is often difficult to simulate conditions of product usage without devising special equipment. The "sliding" machine is one example of such a device. It was developed to measure abrasion resistance of Grex capping under simulated use conditions. A container is placed at the top of the machine, slides through two tracks and is automatically lifted to the top again for a new cycle. In this way it was possible to simulate two years of usage within a short period of time and determine that the capping would provide satisfactory performance.

Other examples. Ingenious is the word to describe other devices specially built to test performance of Grex applications. A mechanical foot was invented to simulate the operation of a step-on garbage can. By running the can through some five thousand cycles, weaknesses were spotted and corrected to make a satisfactory product. Similarly, a method was devised for testing a series of pulleys under identical conditions to determine the most suitable design and resin grade.

Do you want help? Physical testing is only one of several facets of Grace technical service at your command. If you have an application for high density polyethylene—or think you have—now's the time to contact:

Technical Service Department
W. R. Grace & Co., Clifton, N. J.

Twin-lamp legend lights . . .

are used to indicate state of circuit or functions of components in electromechanical equipment. Legends are inscribed on plates that are also lenses of lights. Translucent plastic plates have legend area of $1\frac{1}{16}$ x $\frac{5}{32}$ in. Type is 0.135 in. high for one row of characters (11 max); 0.115 in. high for two rows (11 max). Each light houses two midget, flange-base incandescent bulbs of 6, 14 or 28 v. Finger pressure on release pin opens top plate 110° for removal of lamps from front of panel. Two types of plates are available: dual plates, in which top plate carries legend and underlying plate carries color; or single plate in which no underlying color plate is used. **Dialight Corp, 60 Stewart Ave, Brooklyn 37, NY.**

Circle 317 on Reader Service Card

Spring wire for 600 to 1000 F

is said to cost about one-tenth as much as other, more highly alloyed materials. Precipitation-hardening austenitic alloy is reported to experience as little as half the percent-relaxation loss at 1000 F as comparable alloys at 850 F. Typical mill coil prices range from $2 per lb in 0.199 in. dia to $15 per lb in 0.0035 in. dia. **National-Standard Co, Niles, Mich.** . . .

Circle 318 on Reader Service Card

C-flange gearmotor . . .

is offered off-the-shelf in capacities from 1/12 to 2 hp, reductions from 5:1 to 60:1. Reductions are in increments of 5 up to 30:1; then in increments of 10. Motor and reducer are separated, flange-connected, so that unit can be furnished as complete assembly, or reducer alone can be supplied for application to any standard NEMA motor. **Morse Chain Co, Ithaca, NY.**

Circle 319 on Reader Service Card

Heavy-duty roller chain . . .

has extra clearance between linkplates and between pins and bushings to permit up

continued on page 64

"Precision built for superior performance"
SPHERCO®
BEARINGS & ROD ENDS

AVAILABLE IN A COMPLETE RANGE OF SIZES AND WITH SINTERED BALLS

If you have applications in alving linkage or transfer of motion, SPHERCO Bearings can supply your needs in a wide variety of materials with a quality that will give you top performance under normal or high temperature conditions.

WRITE FOR CATALOG 560

SPHERCO a product of SEALMASTER BEARING DIV.
STEPHENS-ADAMSON MFG. CO., 9 Ridgeway, Aurora, Ill.

VERSATILE,
LONG WEARING,
SLOW AGING
TECHNICAL MEMO ON LINEAR COMPOUNDS 7441-50 & 7446-70
. . . for U-cups, O-rings and other seal configurations
• especially designed for service in hydraulic fluids, lubricating oils and automatic transmission fluids
• good recovery properties, excellent wear resistance
• fully effective sealing from −40° to +212°F; can be used intermittently to +325°F in oil
MATERIALS COMPATIBLE WITH THESE COMPOUNDS:
Alcohol • Corn Oil • Cosmoline 1058 • DTE Oil • Ethylene Glycol • Freon 11 • Freon 12 • G.E. #10 Transformer Oil • Gulf Pride • Gulf XB Grease • Hexane • Houghto-Safe 271 • Hydrolube • Lard • Larex • Lubricating Oils • Lubriplate • MIL-F-25558A • MIL-G-4343 • MIL-H-5606 • MIL-L-9000 • MIL-L-15016 • MIL-L-15017 • Mineral Base Hydraulic Oils • Mo Par Fluid • Olive Oil • Penzoil Trans Oil • Prestone • Sea Water • Shell #532 • Shell Iris 902 • Shell Donax T6 • Shell Northia #41 • Shell Tellus #33 • Shell Tellus #41 • Socony Vactra Oil • Sohivis • Soybean Oil • Suniso #4 • Suniso #7 • Sunoco Dynalube • Suntac #201 • Ucon LB-300X • Ucon 200 N • Univolt #35 • Velocite #1 • Water
For complete technical data—including list of incompatible materials—Request Bulletin 56703-1. Linear Inc., State Road and Levick St., Philadelphia-35, Pa.
PERFECTION IN RUBBER
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

to 4-in. lateral displacement and 8° twist for each 4-ft chain to accommodate sprocket misalignment. Straight linkplates transmit loads in straight line to provide greater load capacity and to withstand higher shock and peak loading. Available in four pitch sizes that are said to meet Military and ASA specifications. For use on heavy construction and industrial machinery. **Diamond Chain Co Inc, Indianapolis 7.**

Circle 320 on Reader Service Card

Time-utilization-meter panel . . .

shows, with pilot lights and time-accumulation figures, productive operations of ten individual mechanisms, machines, processes or operations. Six-digit figures provide for reading totals at any time. Can be quickly reset. Meters are readable to minutes, hours and tenths of hours. Dimensions are 13 x 6⅞ x 4 in. deep. Cost is about $249.50. **Gorrell & Gorrell, 336 Old Hook Rd, Westwood, NJ.**

Circle 321 on Reader Service Card

Spherical roller bearings . . .

contain max number of largest diameter convex rollers. Higher, heavier inner-race shoulders facilitate assembly and removal of bearings from shafts. Retainers are precision-machined and centrifugally cast. **Link-Belt Co, Prudential Plaza, Chicago 1.**

Circle 322 on Reader Service Card

High-power switching device . . .

is three-terminal silicon unit for control of large blocks of power. Characteristics are said to be similar to those of a thyratron because device will block voltage in forward direction below critical breakover voltage. However, by exceeding critical breakover voltage or applying proper gate signal, device will switch to conducting state. Suitable for high power applications at up to 300 v and currents up to 50 amp. Switching time is 600 millimicrosec with peak reserve voltages of 60 to 360 v. Prototype quantities are now available. Prices for 1 to 24 units range

continued on page 68

LOW LABOR CONTENT *the Master Design Guide*

The offset planes, the channels, holes, and functional shapes are all cast to size in the Harper-Wyman gas range top burner part here illustrated.

It is a good example of high utilization of the die casting process for mass production parts.

The Master Design Guide for the seasoned and skilled mechanics at Madison-Kipp, in cooperation with customer designers, is high level quality, from high level tooling for low secondary labor content.

Please clip this ad as a reminder to contact us when you have die casting requirements.

with MADISON-KIPP zinc and aluminum die castings

kipp

MADISON-KIPP CORPORATION
206 WAUBESA STREET • MADISON 10, WIS., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubricating Engineering • Originators of Really High Speed Air Tools

ADVERTISEMENT

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

From the office of
ARTHUR N. DANIELS,
President

RE: Instrument Ball Bearings

Gentlemen:

Most of us didn't learn much about anti-friction bearings in Engineering School. In my own case, we learned the difference between ball, roller and needle bearings, and that's about all. Literature on the subject is sparse; the variety of types, sizes and extra features is vast. All have their limitations, advantages and disadvantages.

This is a plea, then, for taking a Bearing Engineer into consultation before your layouts or designs are frozen. He is a professional and his services are free. We have ten of them, at your disposal, in addition to a staff of specialists at our home office.

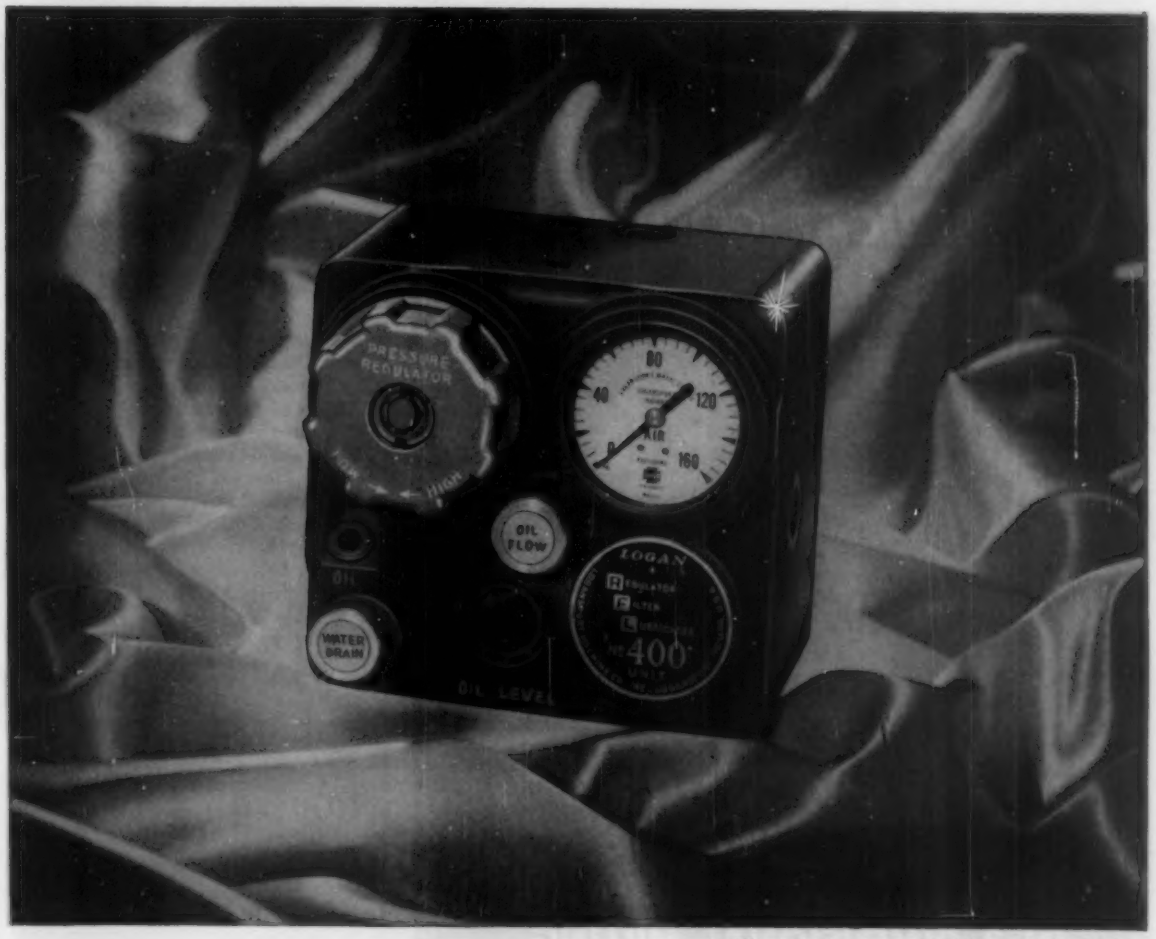
True, they have an axe to grind: to sell you instrument ball bearings. But none of them wants to make recommendations that will fail to meet requirements, or to propose a marginal solution. Ethics of course prohibit their revealing your plans to others. Sometimes they will say "No," or "Maybe," or "Tests must be run." We've not accumulated all the answers yet, doubtless never will. Then, for confirmation, a competitor can be called in. We have a few who know a little about it. And, as sometimes happens among professionals, he may dissent, leaving the judgment up to you.

We believe too that our own new 150-page Design Manual is the most comprehensive treatise on instrument ball bearings published. We shall be glad to send you a registered copy by return mail.

Sincerely,

A. N. Daniels
President

66 CIRCLE 66 ON READER SERVICE CARD



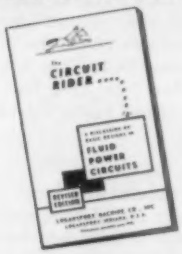
Illustrated—Logan Model 400 RFL Unit

Look to Logan

the ultimate in air circuit accessories

Logan RFL Unit, the designers choice for over a decade! Protects your air-powered equipment . . . regulates pressure . . . filters air . . . lubricates air. Adds years of dependable performance.

New Model 400, illustrated above, is a companion model to the well-known Model 600.



FREE **SEND FOR YOUR COPY OF THE LOGAN "CIRCUIT RIDER" A 32-page manual on fluid power circuits (fifth edition) completely revised to present current engineering trends.**

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
812 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

NAME_____ TITLE_____

COMPANY _____

ADDRESS _____

Last Word In
TAPE READING NUMERICAL CONTROL!

PRATT & WHITNEY NUMERIC-KELLER

IT USES BEAVER BALL SCREWS TO OBTAIN A NEW HIGH DEGREE OF EFFICIENCY IN 3 DIMENSIONAL MILLING

This new machine tool cuts production lead time costs as much as 75%, automatically detects errors and compensates, permits tool change without loss of synchronization and offers many other features.

Table travel is 36" horizontal, 12" traverse, vertical slide moves 22"—and all movements are precision accuated by Beaver Ball Screws, first choice of machine tool designers.

Can our engineers help you obtain

(1) greater accuracy in positioning
(2) minimum break-away friction
(3) greater system stiffness

Beaver engineers are ready to work with you on your actuating problem.

Beaver Precision Products INC.
CLAWSON, MICH.

from $110 to $295 each; for 25 or more, prices range from $85 to $235, depending on type. **Westinghouse Electric Corp, Semiconductor Dept, Youngwood, Penna.**

Circle 323 on Reader Service Card

4PDT slide switch . . .

for multiple switching applications is designed with all terminals in a common plane. Model is not ganged modification, but is integral in one frame with actuating knob. Terminals and contacts are silver plated, and standard units offer over-all distance of 0.575 in. nominal from mounting surface to extreme tip of terminal. Volume under mounting surface is slightly over 0.5 cu. in. Switch has phenolic black knob, $\frac{3}{4}$ in. high. **Continental-Wirt Electronics Corp, 5221 Greene St, Philadelphia 44.**

Circle 324 on Reader Service Card

Electric counter . . .

is reported to give accurate counts at high, medium or low speeds, to offer life rating of 30 million counts min at speed of 1000 cpm. Operating speeds to 1200 cpm are possible at normal voltage. Has fast-operating solenoid with built-in rectifier for ac operation. Solenoid operation escapement mechanism has only one moving part, in addition to number wheels and reset shaft. **Durant Mfg Co, 1938 N Buffum St, Milwaukee 1.**

Circle 325 on Reader Service Card

Variable-volume pump . . .

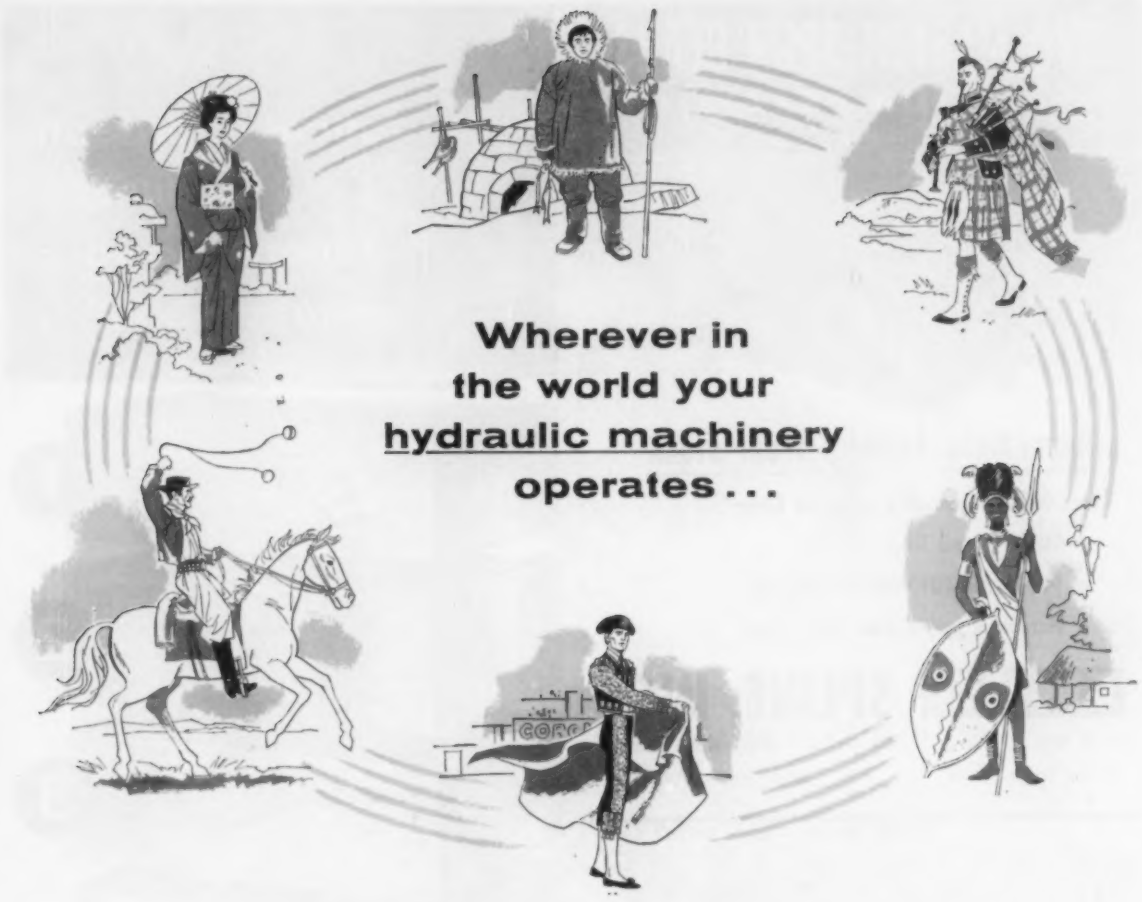
of axial-piston type has pressure-compensator control. Delivers about 27 gpm at 3750 rpm and 3000 psi, with max displacement of 1.77 cu in. per rev. Weighs 17½ lb. **American Brake Shoe Co, Dept A, 530 Fifth Ave, New York 36.**

Circle 326 on Reader Service Card

Ultrasonic soldering iron . . .

capable of soldering wide range of materials without flux is being sold for $249. The 8-oz, 10-w unit is suitable for solder-

continued on page 73



Shell Tellus Oil is there

Other outstanding Shell Industrial Lubricants available world-wide

- **Shell Rimula Oils** – for heavy-duty diesel engines
- **Shell Talona R Oil 40** – anti-wear crankcase oil for diesel locomotives
- **Shell Alvania Grease** – multi-purpose industrial grease
- **Shell Turbo Oils** – for utility, industrial and marine turbines
- **Shell Dromus Oils** – soluble cutting oils for high-production metalworking
- **Shell Macoma Oils** – for extreme pressure industrial gear lubrication
- **Shell Voluta Oils** – for high-speed quenching with maximum stability

Around the world, Shell Tellus Oil is available—under the same brand name and providing the same performance that your domestic customers rely upon.

Tellus® Oil is top-rated as both a lubricant and control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge formation, wear and foaming has earned it world-wide popularity.

No matter where your hydraulic machinery is shipped, make Shell Tellus Oil your standard recommendation. Write for complete information.

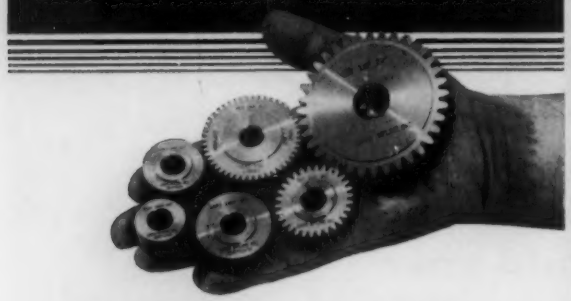
AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the **Cultellus** costatus.

SHELL OIL COMPANY

50 WEST 50TH STREET . . . . . NEW YORK 20, N. Y.
100 BUSH STREET . . . . . SAN FRANCISCO 6, CALIFORNIA
IN CANADA: SHELL OIL COMPANY OF CANADA, LIMITED
505 UNIVERSITY AVENUE . . . . . TORONTO 2, ONTARIO

SHELL

INVO MASTER SPUR GEARS
ULTRA-HIGH PRECISION



Immediate delivery from stock

- .0002 Maximum Composite Error
- 20 Pitch and Finer
- 14½° and 20° Pressure Angles
- Hardened and Ground Tool Steel

INVO SPLINE, INC.

P. O. BOX 25 • HAZEL PARK, MICH.

PHONE SLocum 7-8840 SEND FOR STOCK LIST

CIRCLE 204 ON READER SERVICE CARD

free catalog

ALLEN AIR VALVES

Technical catalog (with prices listed) — yours for the asking.

WRITE BEFORE NEXT TUESDAY

ALLENAIR CORP., 255 East 2nd St., Mineola, N. Y.

Name .....

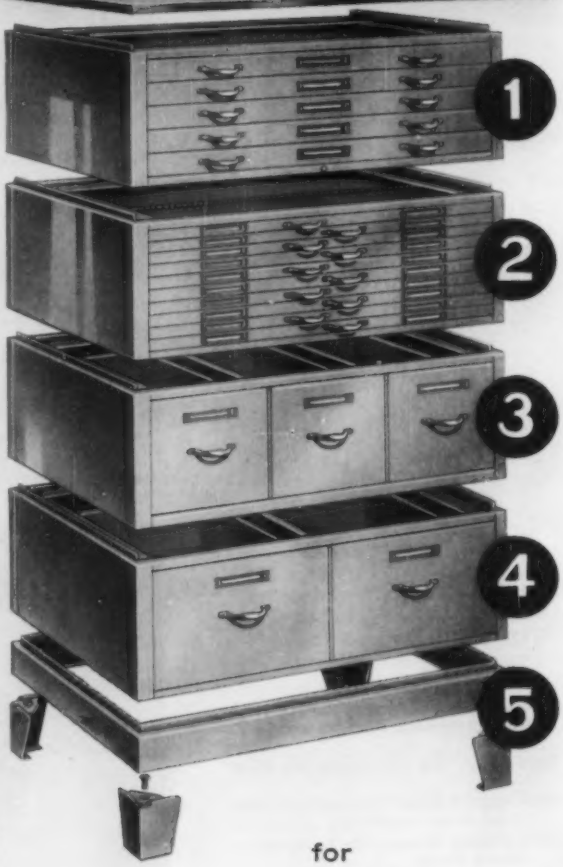
Company .....

Address .....

City ..... Zone ..... State .....

PEG-6

A practical approach to filing— tailored to your requirements...



for more efficient

PROTECTION

ACCESSIBILITY

CLASSIFICATION

UTILIZATION OF SPACE

HAMILTON INTERLOCKING UNIT SYSTEM

BUILD THE UNIT SYSTEM TO FIT YOUR INDIVIDUAL NEEDS

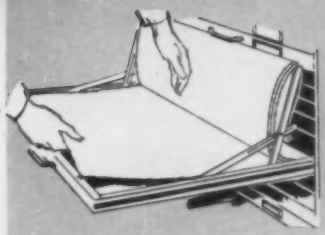
with various combinations of these compatible, interlocking Hamilton filing units: ❶ *Five-drawer unit.* For semiactive tracings, drawings, prints. 2-inch drawers with dust covers protect sheets, floating rear hood prevents curling. Partitions for fractional size sheets. Available in 3 unit system sizes. ❷ *Ten-drawer unit.* Greater active capacity—up to 1000 sheets. Each drawer has patented tracing lifter mechanism. Finer classification system, 20 classification tabs, 3 sizes. ❸ and ❹ *Vertical units.* 2 and 3-drawer units for safe, efficient vertical filing of small sheets. Each drawer has 60 folders with index tabs, held firmly in place by Hamilton Tracing Suspension System. 2-drawer unit holds up to 6000 active tracings, 9000 inactive tracings; 3-drawer up to 9000 active or 13,000 inactive tracings. Interlocks with smallest of 3 unit system sizes. ❺ *Interlocking caps and bases.* Units become single, compact filing center with addition of caps and bases. Removable cap completes assembly, provides further protection. Bases available for variety of stack heights.

Interlocking roll tracing units available as illustrated at right.

FREE FILING ANALYSIS—Hamilton's experienced planning department will gladly provide analysis and layout of filing facilities based on your specific size, space, and personnel requirements. Ask your dealer, or write our Planning Department.

For complete specifications, sizes and details on all Hamilton Filing units and drafting room equipment, send for our free catalog.

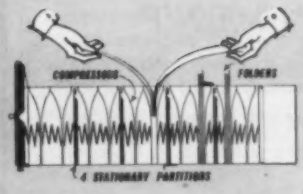
Hamilton
PROFESSIONAL AND SCIENTIFIC FURNITURE
Hamilton Manufacturing Company, Two Rivers, Wis.



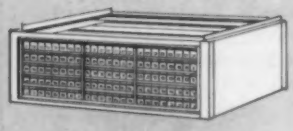
Patented Tracing Lifting Device is key to accessibility. Top tracings fold over lifting device, selected sheet may be removed and replaced quickly and easily, without damage. Standard in 10-drawer units.

THESE EXCLUSIVE HAMILTON FEATURES PROVIDE GREATER FILING EFFICIENCY

Dust Covers are coated fabric, provide complete protection from dust and dirt, keep tracings compressed, safe, and clean. Standard in all drawers.



Tracing Suspension System in vertical units holds folders upright, firmly in place. Coil springs provide even pressure on each side of folder, permit easy removal and replacement of small tracings.



Roll Tracing Unit provides fully enclosed protection for long tracings. Tracings are rolled, slipped into steel trays. Each tray labeled for easy classification. 2 sizes, for 37" and 43" rolls. Will interlock with two largest unit system sizes.

new dimensions in time and space efficiency for: physicians; dentists; industrial, hospital, school laboratories; draftsmen, printers; libraries; home laundries

CIRCLE 71 ON READER SERVICE CARD

ANOTHER ROSÁN ENGINEERING ACHIEVEMENT

*SLIMSERT. . . . . the insert designed to meet the requirements of the space age. A one piece stainless steel column embodying the ultimate in fastener design criteria.

HIGH STRENGTH • LIGHT WEIGHT • WIDE TEMPERATURE RANGE • NON CORROSIVE • POSITIVE EXTERNAL LOCK • EXTENDED LIFE INTERNAL LOCK • WASTE FREE INSTALLATION.

Can be installed in smallest boss diameter. Ideal for the replacement of wire type inserts.

Send for 20 page Engineering Data Book.
Address Mr. R. Weber.

ROSAN, INC.
8501 West Coast Highway • Newport Beach, California

*A trademark of Rosán Engineering Corp.

72 CIRCLE 72 ON READER SERVICE CARD

New!

ENGINEERING CATALOG for Power Transmission Couplings

A Guide to Correct Flexible Coupling Selection

In the new Thomas Engineering Catalog "60" misalignment is described and the customer is assisted in selecting the coupling most suitable for his requirements.

Loads are classified and styles of couplings are grouped for easy selection. Also shown are facts about dynamic balancing, bore and keyway standards, photographs of installations and diagrams and tables for each type of coupling as well as a complete line of miniature couplings.

Write for your copy today.

THOMAS FLEXIBLE COUPLINGS

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U. S. A.

CIRCLE 205 ON READER SERVICE CARD

standard instrument cases
(At Off-The-Shelf Prices)

Learn how TA's new predesigned Instrument Cases can solve your equipment housing problems.

Send for your FREE copies . . .

TA mfg. corp.

These free design manuals show how TA's exclusive features can be quickly and easily adapted to solve your equipment housing problems.

- Large selection of standard sizes and styles.
- Available in depths from 2½ to 18 inches.
- Fast delivery (prototypes in 4 weeks).
- Wide choice of standard handles, access doors, panels, and other accessories.
- No tooling charges on standards.
- Free engineering drawings for your exclusive design requirements.

STANDARD ALUMINUM CONSTRUCTION

TA Mfg. Corp.
4607 Alger Street • Los Angeles 39, Calif.
(or call CH 5-3748)
TWX 9963 Glendale, Calif. • WUX CAT Los Angeles, Calif.

CIRCLE 206 ON READER SERVICE CARD

ing semiconductor materials, as well as metals. Operates on normal 115-v, 60 cps power. Gulton Industries Inc, 212 Durham Ave, Metuchen, NJ.

Circle 327 on Reader Service Card

Miniature switch . . .

with overtravel plunger for cam actuation in rotary applications is said to have electrical and environmental characteristics that meet requirements of MS-25085. Available with drilled single- or double-turret terminals. Switch is 1 1/16 x 1/2 x 0.871 in. high. Overtravel is 0.060 in. min; pretravel is 0.015 in. max; operating force is 10 oz max. Return force is 1 oz min; movement differential, 0.001 in. max. Milli-Switch Corp, Gladwyne, Penna.

Circle 328 on Reader Service Card

Miniature solid-state voltage regulator . . .

accepts unregulated direct voltages of 24 to 34 v and provides regulated direct output voltages of 24, 26, 28, 30 or 32 v. Has encapsulated components and is lightweight. Said to be environmentally tested to meet severe conditions. Applicable for providing regulated voltages to timing and actuating mechanisms and to servomotors. Acton Laboratories Inc, 533 Main St, Acton, Mass.

Circle 329 on Reader Service Card

Thermoelectric experimental kit . . .

is for study of thermoelectric principles. Basic unit of kit is thermoelectric module known as a Frigistor, consisting of eight thermocouples fabricated from a new semiconductor material. Module can be used to modify existing products or to design new devices. Low-voltage power supply, which will drive one or more modules, has been designed for the package. General Thermoelectric Corp, PO Box 253, Princeton, NJ.

Circle 330 on Reader Service Card

"Maybe you ought to dilute it a little."

Hub assembly with integral preloaded duplex ball bearing, used in electronic missile system developed by Westinghouse Air Arm.

"IN-BORN" BEARING IN HUB ASSEMBLY

Gives Better Accuracy, Weight and Cost

Important advantages can often be gained by "designing in" bearings as a part of the unit in which they operate. A case in point is this hub assembly, produced and bearing-engineered by ITI.

Here, the two outer raceways and one inner raceway are formed in the hub and shaft; and the second inner ring – made separate to permit assembly – is close to a zero-tolerance fit. Compared to the usual design (using separate bearings), this construction gives (1) higher and more uniform accuracy, through elimination of 6 radial tolerances; (2) less weight and greater compactness, by eliminating 3 rings; and (3) lower total cost.

Other features include low running torque, labyrinth seals, high vibration resistance, and a dished hub held within .001" of the mathematically-specified contour.

In comparable ways, you too can benefit through our ability to design and produce bearings having unusual compactness or configuration, heat resistance, corrosion resistance, ultra precision, or other special properties. Let's talk it over.

FREE BULLETIN AFB-2 tells about the factors involved in special bearing applications, describes our work in this field, and shows a wide variety of special bearings. Write for it!

INDUSTRIAL TECTONICS, Inc.

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3667 JACKSON RD., ANN ARBOR, MICH.

BEARING DIVISION PLANT: COMPTON, CALIFORNIA

CIRCLE 73 ON READER SERVICE CARD 73

PROTECT YOUR PRODUCTS WITH LOW COST

LISLE *Magnetic* **PLUGS**

If your product has moving parts operating in a fluid, you can reduce costly wear with Lisle Magnetic Plugs.

Ferrous metal particles in a lubricant are a major cause of wear. The Lisle Magnetic Plug removes these particles from the lubricant — assures longer, quieter operation of the products you make.

Lisle Magnetic Plugs can be used in place of any ordinary drain or fill plug.

FREE Samples for Testing in Your Product!

LISLE CORPORATION
Clarinda, Iowa

DESIGN LITERATURE

Engineering Data Processing

ARTHUR D EVEN. D Van Nostrand Co Inc, 120 Alexander St, Princeton, NJ. 6¼ x 9¼, 282 pp. $6.50.

Electronic data-processing machinery, though chiefly a tool to speed accounting methods, also has some important potentialities in the engineering department. Here, paperwork (drawings, parts lists, change notices and drawing records) is abundant, and until recently there was no way to put these outsize documents into the familiar punched-card form. But today, the accounting-machine card with an aperture for microfilm has been perfected to the point where it is practical for all but the smallest engineering organizations. This book describes the methods and equipment involved in the changeover of engineering-record handling from a manual system to a mechanized one.

The author begins with a description of the common engineering documents and the basic concepts of a system for handling them with electronic equipment. Following chapters discuss installation, operation and control of the system and the provisions necessary for expanding it to handle future loads. An actual installation is described, including a set of sample forms taken from a successful system. The book is illustrated with pictures of typical equipment and includes a detailed glossary of terms commonly used in the data-processing and microfilming industry.

Fundamentals of Stress Analysis

DEYARMOND and ARSLAN. Aero Publishers Inc, 2162 Sunset Blvd, Los Angeles 26. 6 x 9, 256 pp, $5.75.

Since the first edition was first published, many changes have taken place within the aircraft industry. One no longer thinks of just wings and fuselages and tail surfaces when discussing aeronautics, because that term now encompasses rockets and missiles as well as the guidance systems that are involved with missile firing and control.

However, the fundamental principles of structural analysis remain unchanged. The engineer who is preparing himself for handling analysis and design work must first know the basic theories of beams, trusses, beam-columns, etc, all of which are the same whether he is designing a unit for an airframe or a missile component.

This text begins with basic fundamentals of stress and strain and, in a clearly written fashion, takes the reader on through analyses of complex structural shapes. An appendix gives handy charts and design equations.

Mechanics of Materials

HIGDON, OHLSEN & STILES. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 10 x 7, 502 pp. $7.75.

This book is designed to emphasize the required fundamental principles, with numerous applications to demonstrate and develop logical orderly methods of procedure. Instead of deriving numerous formulas for all types of problems, the use of free-body diagrams and the equations of equilibrium are stressed.

From Tinfoil to Stereo

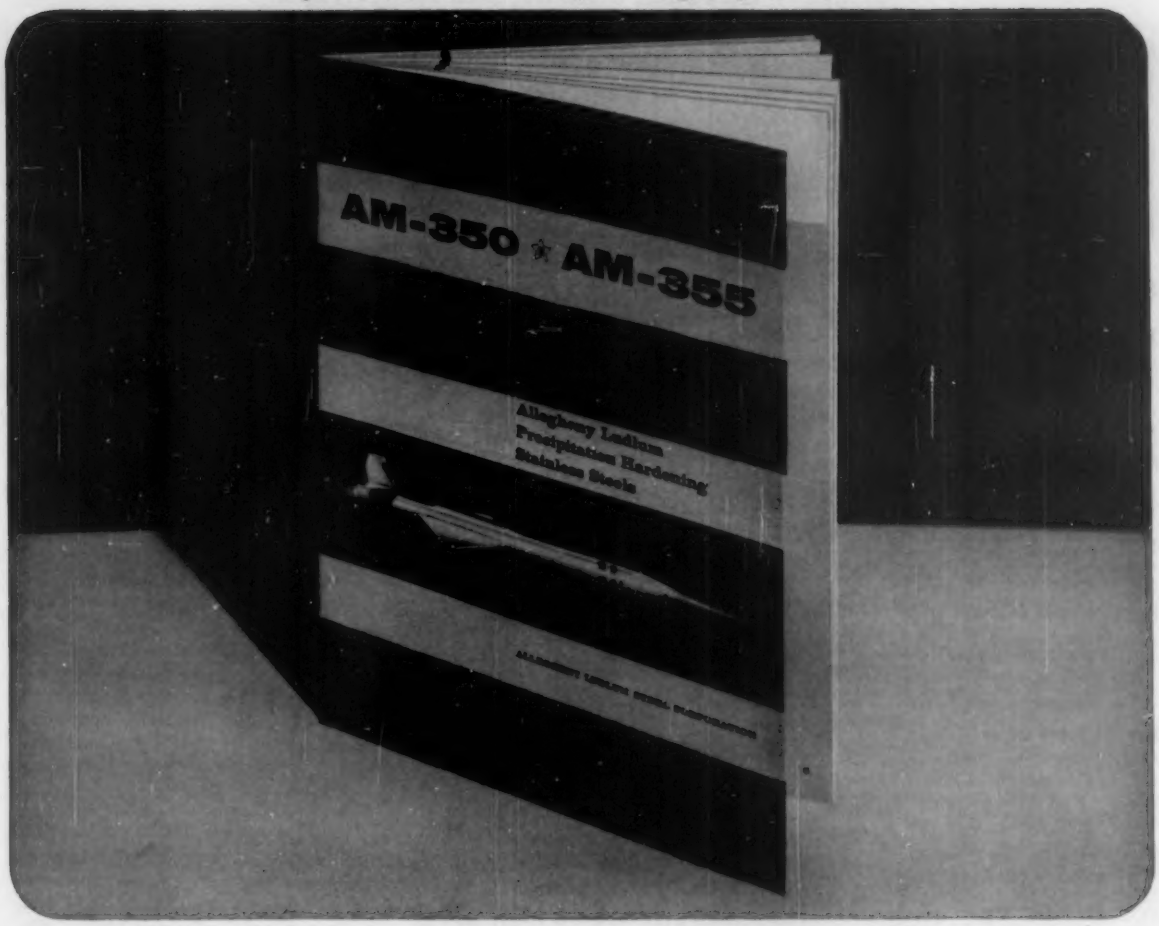
OLIVER READ and WALTER WELCH. Howard W Sams & Co Inc, and Bobbs-Merrill Co Inc, 1720 E 38th St, Indianapolis. 9¼ x 6¼, 524 pp. $9.95.

The phonograph has been an interesting invention not just as an engineering development, but in a business sense as well. Soon after Edison came out with his development, it seemed that several other inventors had prior claim to the invention. Men like Bell, Tainter Scott and Bettini

continued on page 76

"I just figured it out! If that new guy has worked everywhere he says—he's one hundred and seven years old!"

Experience—*the added alloy in* **Allegheny Stainless**



New booklet on A-L's precipitation-hardening stainless steels, AM-350 and AM-355

A tool for anyone interested in high strength-to-weight metals

In this technical booklet, you get the facts on Allegheny Ludlum's precipitation hardening stainless steels, AM-350 and AM-355, metals developed for space age requirements.

AM-350 and AM-355 combine these unusual qualities. They are easy to fabricate. Have high strength-to-weight ratios at room and elevated temperatures combined with excellent resistance to corrosion.

The physical and mechanical properties of the two metals are described in 33 charts and tables. Included are heat-treatment and fabrication data, eight photomicrographs and a section on corrosion resistance with representative values in selected environments.

It's jam-packed with data. For your free copy, see your A-L representative or write *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. PE-6.*

ALLEGHENY LUDLUM

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

AL

CIRCLE 75 ON READER SERVICE CARD 75

jumped on an I-thought-of-it-first bandwagon. This book reviews the claims of those men and others and, with reproductions of the original patents plus pictures, tries to settle the question. The book takes us beyond the phonograph's development, presenting information on the latest in hi-fi and stereo.

Other Books of Interest

Technical Communication

G C Harwell. Macmillan Co, 60 Fifth Ave, NY 11. 5½ x 8½, 332 pp, $3.75.

Applies principles of good writing to technical and scientific reports, articles, letters, oral communications, illustrative material.

Mathematics in Action

O G Sutton. Harper & Bros, 49 E 33rd St, NY 16. 5¼ x 8, 231 pp, $1.45.

Discusses some of the principal applications of mathematics to modern science and technology, evaluates influence, particularly on the nature of the physical universe. Paperback reprint of original published in 1954.

Physics and Microphysics

L deBroglie. Harper & Bros, 49 E 33rd St, NY 16. 5¼ x 8, 282 pp, $1.50.

Expositions on physics and the history and philosophy of science. Paperback edition of volume published originally in 1955.

FBI Register of British Manufacturers—1960

Iliffe & Sons Ltd, Dorset House, Stamford St, London SET, England. 9½ x 7½, 1164 pp. Approximately $5.60.

Chemistry for Our Times

Weaver, Foster. McGraw-Hill Book Co Inc, 330 W 42 St, NY 36. 6½ x 9½, 666 pp. $5.72.

Highschool text.

Physical Metallurgy of Stress-corrosion Fracture

T N Rhodin. Interscience Publishers, 250 Fifth Ave, NY 1. 6 x 9¼, 394 pp. $13.

ASTM Standards on Copper and Copper Alloys

American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6¼ x 9¼, 704 pp. $7.50 nonmembers; $6 members.

Petroleum Products Handbook

V B Guthrie. McGraw-Hill Book Co Inc, 330 W 42 St, NY 36. 6¼ x 9¼, 2 in. thick. $18.50.

ASTM Standards 1959 Supplements to Book of

American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9. $4 per part, $40 per set. The 10 parts: 1—Ferrous Metals (specifications); 2—Nonferrous Metals (specifications), Electronic Materials; 3—Methods of Testing Metals; 4—Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils; 5—Masonry Products, Ceramics, Thermal Insulation, Acoustical Materials, Sandwich and Building Constructions, Fire Tests; 6—Wood, Paper, Shipping Containers, Adhesives, Cellulose, Leather, Casein; 7—Petroleum Products, Lubricants, Tank Measurement, Engine Tests; 8—Paint, Naval Stores, Aromatic Hydrocarbons, Coal and Coke, Gaseous Fuels, Engine Antifreezes; 9—Plastics, Electrical Insulation, Rubber, Carbon Black; 10—Textiles, Soap, Water, Atmospheric Analysis, Wax Polishes.

Inventories and Business Health

Business Publications Div, Dun & Bradstreet Inc, PO Box 803, Church St Station, NY 8. $1.

Relationship of inventory size to condition of a business and factors influencing inventory values.

Proceedings of the 1959 Institute in Technical and Industrial Communications

Dr H M Weisman, Dr R C Nelson. Institute in Technical and Industrial Communications, Colorado State Univ, Fort Collins, Colorado. $5.

Presentations by professionals in Technical writing field.

Aerospace Marketing Handbook

Defense Marketing Services Inc, 600 N Sepulveda Blvd, Los Angeles 49. 9¼ x 11½, listed alphabetically. $175 per yr, including 11 monthly supplements.

Describes development and/or production status of all publicly identified missile and space programs of both military and civilian agencies.

Directory of Firms, Their Buyers and Specifying Engineers

Industries Publishing Co, PO Box 621, Culver City, Calif. 6 x 8½, 130 pp, $25.

Lists buyers and specifying engineers in aircraft, missile, space and electronic industries in 11 Western states.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 81.

INDUSTRIAL PERFORATED METAL—Brochure 8159, 40 pp. Covers applications, pattern specification, dimensions, unit weights, calculation of open area, materials selection, fastening methods and equivalence tables relating wire cloth to square, round and hexagonal patterns. Cross Perforated Metals, National-Standard Co, Niles, Mich.

Circle 350 on Reader Service Card

PRESSURE REGULATORS—Folder, 12 pp. Presents RV-23 series of manual or electrically operated and remotely controlled pressure regulators. Schematic diagrams, flow charts, installation data and auxiliary components are included. Marotta Valve Corp, PO Box 330, Boonton, NJ.

Circle 351 on Reader Service Card

GASKETING AND GASKETS—Catalog and pricelist GG-1259, 12 pp. Sectionalized and indexed catalog provides information on 14 different types of sheet packings; compressed asbestos-ring and full-face gaskets; handhole- and manhole-size, wire-inserted, folded asbestos gaskets and six different types of tape, rope, lagging and wick packings. Greene, Tweed & Co, North Wales, Penna.

Circle 352 on Reader Service Card

SILICONES AND THEIR USES—Brochure, 16 pp. Summarizes forms, properties and applications of silicones. Illustrated with photos, tables and graphs. Dow Corning Corp, Midland, Mich.

Circle 353 on Reader Service Card

METAL-PRODUCTS FACILITIES—Brochure, 12 pp. Describes facilities for producing products in magnesium, aluminum and other metals. Dow Metal Products Co, Hopkins Bldg, Midland, Mich.

Circle 354 on Reader Service Card

TRACING TEMPLETS FOR CYLINDERS—Form 360, 16 pp. Contains full-size tracing templets of small-size hydraulic and pneumatic cylinders. Chart lists max recommended strokes for various mountings. Also includes price list and weight chart. Control Line Equipment, 19560 Center Ridge Rd., Cleveland 16.

Circle 355 on Reader Service Card

ROTARY PUMPS—Manual, 18 pp. Liquids have been grouped into eight classifications, according to viscosity, and each classification has its own rotary-pump selection table. Deming Co, Salem, Ohio.

Circle 356 on Reader Service Card

CIRCUIT-BREAKER LOAD CENTERS—Bulletin GEA-7071, 16 pp. Provides descriptive information and specifications on load centerline, from 2 to 40 circuits, 40 to 200 amp, in flush, surface and raintight enclosures. General Electric Co, Plainville, Conn.

Circle 357 on Reader Service Card

DC POWER SUPPLIES—Catalog E60, 16 pp. Lists 125 standard and custom power supplies. Discusses selection of proper type. Perkin Engineering Corp, 345 Kansas St, El Segundo, Calif.

Circle 358 on Reader Service Card

ZIPPER TUBING—Catalog Z-2, 4 pp. Specifications and sizes of zipper tubing. Alpha Wire Corp, 200 Varick St, New York 14.

Circle 359 on Reader Service Card

PRODUCT APPEARANCE—Booklet, 6 pp. Discusses the role of product appearance as a factor in sales. Illustrated with case histories. Mast Development Co Inc, 2212 E 12th St, Davenport 16, Iowa.

Circle 360 on Reader Service Card

INDUSTRIAL SEMICONDUCTOR PRODUCTS—Bulletin, 12 pp. Lists major specifications of industrial semiconductor products. Also contained in the brochure is information on reliability

continued on page 79

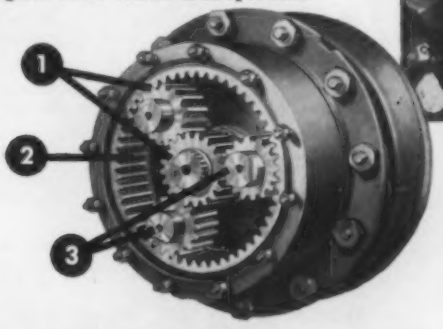
Rockwell's refined full planetary design has these exclusive features:

1. **FLOATING RING AND SUN GEARS** assure equal distribution of stresses to all planetary gears.

2. **CONCENTRICALLY MOUNTED RING GEAR** allows perfect alignment and fit—plus freedom of bending forces on hub and spindle splines.

3. **FORGED ALLOY BRONZE PLANET PINION PINS** have rifle drilled lubrication channels and machined lubrication flats to assure full-time lubrication.

4. **FULL FLOW LUBRICATION** design gives constant flow of lubricant to wheel bearings and all planet gears while vehicle is in operation.



"TIMKEN-DETROIT® PLANETARY AXLES

BEST DRIVE FOR THE HEAVYWEIGHTS!"

Here's new rugged dependability for prime movers, four-wheel tractors, heavy off-road wagons, mining and agricultural equipment, and many other heavy-duty applications. Rockwell-Standard's complete line of planetary axles are available in capacities up to 150,000 pounds. And to meet every job need, there is a planetary steering axle operationally matched to each rigid planetary in the line.

The large reductions possible with Rockwell's full planetary, double-reduction axles enable them to ideally perform most heavy-duty off-highway operations. Because the substantial planetary reduction is located in the wheel hub, axle shafts and first reduction gears carry only nominal torsional loads—give long trouble-free service. For the best heavyweight drive, specify Timken-Detroit.

Another Product of...

ROCKWELL-STANDARD CORPORATION

ROCKWELL R STANDARD ®

Transmission and Axle Division, Detroit 32, Michigan

CIRCLE 77 ON READER SERVICE CARD

RAPID ADVANCES ARE BEING MADE WITH

PRINTED CIRCUITS

...and you ought to know all about them!

ARE YOU AWARE...

- that you now can produce printed circuits on two sides of a base board *without mechanical conductors?*
- that you can eliminate eyelets, eyelet setters and machine operators?
- that you can reduce rejects . . . cut out failure in use from vibration . . . increase the efficiency of the circuit?
- that unless the base board is properly cleaned and prepared, failure is virtually certain?
- that new uses, new economies, new production short-cuts are being developed daily . . . and that you can get in on the latest know-how right now?

The MacDermid representative has the know-how to help you with any of your problems.

Write today for your free copy of MacDermid's new "Printed Circuit Manual"

It's loaded with production tips, technical data sheets, information on the best chemicals and compounds to produce printed circuits efficiently . . . plus timely warnings that may save thousands of dollars on your production line.

For your free copy, just write . . .

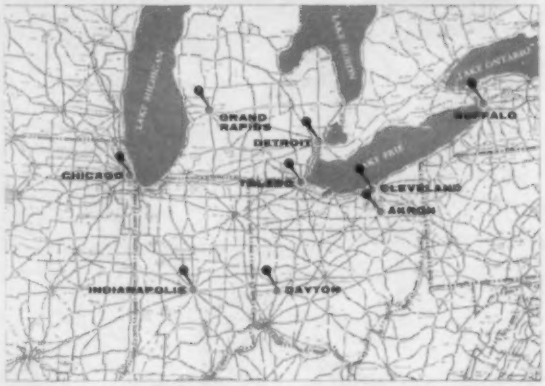
MacDermid, Dept. PE, Waterbury 20, Conn.

MacDermid INCORPORATED ...right to the Finish!

WATERBURY, CONNECTICUT

PENINSULAR'S Team of 9 Steel Service Centers working together to give you STEEL plus SERVICE

America's Largest Independent Tool Steel Distributor



TOOL STEELS • ALLOYS • COLD DRAWN • HOLLOBAR
FLAT GROUND STOCK • DRILL ROD • PLATE

Over 40 Years of Service to Industry

PENINSULAR STEEL COMPANY

24401 GROESBECK • P. O. BOX 3853 • DETROIT 5, MICHIGAN
DREXEL 1-9400 • PRESCOTT 8-2121

DETROIT • CLEVELAND • INDIANAPOLIS • TOLEDO • AKRON • DAYTON • CHICAGO • GRAND RAPIDS • BUFFALO

CIRCLE 207 ON READER SERVICE CARD

SIMPLIFY DESIGN PROBLEMS

Uneven loads will not sway, tip or tilt because off-center load is evenly distributed on both springs. Variable ratio springing adjusts self to road conditions. Deflection rate changes automatically to produce exactly right capacity to properly balance spring tension with load. Lower center of gravity without sacrifice of clearance. Only four bolts to mount . . . no assembly required. Just two friction bearings with renewable friction inserts control spring action.

Prior LEVEL-LOAD TRAILER AXLE

PRIOR PRODUCTS, INC. / P. O. BOX 7608 • DALLAS, TEXAS

CIRCLE 208 ON READER SERVICE CARD

program in which industrial semiconductors are subjected to electrical, mechanical, environmental and life tests. Motorola Inc, Semiconductor Products Div, 5005 E McDowell Rd, Phoenix, Ariz.

Circle 361 on Reader Service Card

SMALL-ENGINE CARBURETOR—Catalog, 8 pp. Offers information on general application, parts identification, service adjustments and tune-up specifications for UT, N and ND model small-engine carbureters. Carter Carburetor Div, ACF Industries Inc, St Louis 7.

Circle 362 on Reader Service Card

VARIABLE-CAPACITY PUMPS – Bulletin 600, 8 pp. Describes line of variable-capacity, rotary pumps; explains principle of opeartion. Includes four cutaway illustrations of basic models. Also provides guide to selection. Blackmer Pump Co, Grand Rapids 9, Mich.

Circle 363 on Reader Service Card

MOLDED NYLON PARTS—Catalog, 6 pp. Specifications, dimensional drawings and prices of stock nylon parts. Nylomatic Corp, 191 W Trenton Ave, Morrisville, Penna.

Circle 364 on Reader Service Card

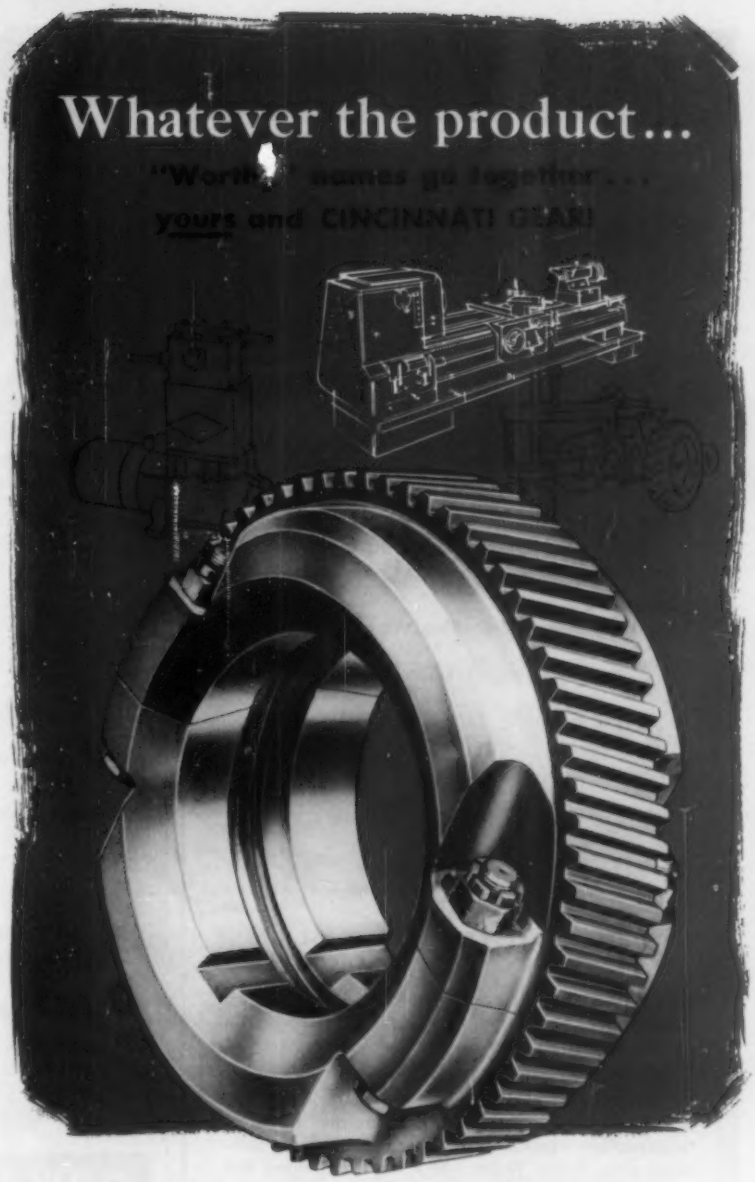
U-RING—Bulletin UR-360, 4 pp. Design features and construction are described. With dimensional cutaway sectional views and schematic diagrams of typical application installations. Greene, Tweed & Co, North Wales, Penna.

Circle 365 on Reader Service Card

LAB AND TESTING INSTRUMENTS—Folder E-6, 16 pp. Specifications, application information and prices of portable potentiometers, dc galvanometers, ac

continued on page 81

"Hold on a minute! You fellows trying to make a monkey out of me?"



This trademark on a gear is the GUARANTEE of a quality-conscious gear manufacturer.

CINCINNATI GEAR has kept in the forefront of technological progress in gear-making methods and equipment for over 50 years. The oldest "tool" in our ultra-modern shop is *pride in true craftsmanship!*

Send for NEW 32-page Technical Brochure

CINTI

THE CINCINNATI GEAR CO.

Wooster Pike and Mariemont Ave. Cincinnati 27, Ohio
Custom Gear Makers Since 1907

GEARS, good gears only

FABROID® Self-Lubricating BEARINGS

REDUCE . . .
costs, wear, maintenance, and friction

PROVIDE . . .
reliability, weight-saving, nearly-equal starting and running coefficients of friction

ELIMINATE . . .
lubrication, fretting, brinelling, use of seals

MAGNIFIED PHOTOGRAPHS OF FABROID

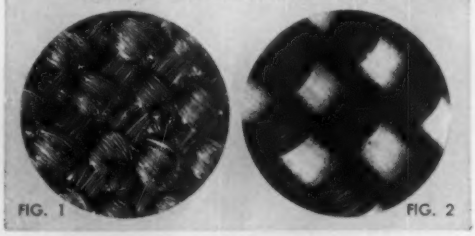


FIG. 1 FIG. 2

10X-STRENGTH PROVIDES MAXIMUM LIFE FOR LOW-SPEED, HIGH-LOAD APPLICATIONS

FABROID consists of two fused layers. The bearing layer (Fig. 1) is a weave of Teflon* fibers interwoven on the back with a layer of phenolic-impregnated glass fibers of high tensile strength (light strands in Fig. 2).

Bonding the two layers under pressure and elevated temperature results in a dense lattice of self-lubricating Teflon fibers which have ten times the strength of other Teflon forms.

**E. I. Dupont's Tetrafluorethylene*

FABROID solves these bearing problems . . .

- Lubrication and maintenance
- Extreme temperatures
- Tight space, weight conditions
- Abrading, galling, or corrosion
- Contamination
- Static Friction
- Shock and vibration

There Is No Substitute For Fabroid Bearings

U.S. Pat. No's. 2,804,886; 2,835,521; 2,885,248

MICRO-PRECISION DIVISION

Micromatic Hone Corporation
1535 Grande Vista Ave.
Los Angeles 23, California
PHONE: ANgeles 8-1345

MOLDING

for the Furniture Industry

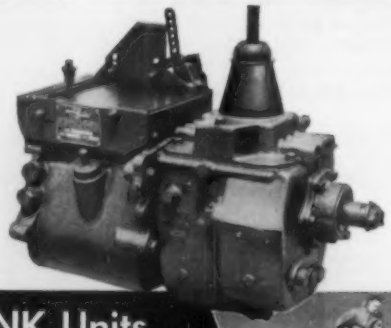
Not only does Patent offer custom plastic molded legs for sofas, chairs, tables, hassocks, television sets, etc., but service to many other industries as well. Complete facilities for compression, injection and plunger type molding provide unlimited product design. Send your inquiry today!

PLASTIC MOLDING DIVISION OF

Patent BUTTON CO. of TENN. Inc.

KNOXVILLE, TENNESSEE PHONE 2-9621

CIRCLE 209 ON READER SERVICE CARD



FUNK Units give this tractor *EXTRA* performance!

Smooth, instant power shifting — both forward and reverse — with just one lever!
And this FUNK Revers-O-Matic® Drive installation provides neutral speed control for Napco, leaves driver's hands free for other operations.
Just one example of how FUNK MODULAR POWER UNITS may be combined — in an unlimited number of arrangements — without special engineering costs.

Let FUNK solve your power transmission problem.

FUNK MFG. CO. Box 577-D, Coffeyville, Kansas

and dc null detector, guarded Wheatstone Bridge facility, universal ratio set and electrolytic conductivity indicators. Leeds & Northrup Co, 4934 Stenton Ave, Philadelphia 44.

Circle 366 on Reader Service Card

BONDING INSULATION MATERIALS—Chart, 4 pp. Information and specifications on proper types of adhesives to be used in varying applications involving insulation projects. Miracle Adhesives Corp, 250 Pettit Ave, Bellmore, NY.

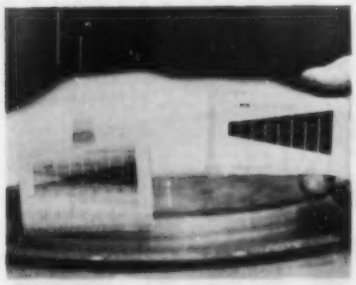
Circle 367 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

MAKE OR BUY—Brochure, 12 pp. Compilation of results of study to determine economic feasibility of maintaining a screw machine department or purchasing screw machine products from independent producers. Report is documented by statistics from both US Government agencies and NSMPA. National Screw Machine Products Assoc, NSMPA Bldg, 2860 E 130th St, Cleveland 20.

SAFETY STANDARDS FOR COMPRESSOR SYSTEMS—Third draft of proposed American Standard, B19.1. Copies of the proposal are available for criticism and comment. American Society of Mechanical Engineers, 29 W 39th St, New York 18.



VIBRATION-TEST MEASUREMENT—Pressure-sensitive, wedge-shaped sticker that can be affixed to flat surface on object under test. As wedge vibrates with test piece, two triangles appear. Displacement is indicated on scale directly below point of darkest triangle. MB Electronics, 781 Whalley Ave, New Haven 8, Conn.

THIN-SECTIONED BALL-BEARINGS Bulletin S-112R, 28 pp. Presents specifications and prices for off-the-shelf, ball, radial-type, CP, thin-sectioned, large-bore ball-bearings includes 23 drawings of commercial and space-age designs incorporating the bearings. Kaydon Engineering Corp, McCracken St, Muskegon, Mich.

WORLD BESTOS BRAKE LINING

...any *shape*...any *size*...any *friction* to meet your most exacting requirements!

ROUND

as for Race Cars

INTRICATE

as for Industrial Brakes

TINY

as for small Precision Assemblies

BIG

as for giant Forming Presses

● World Bestos is currently helping many manufacturers solve difficult braking problems with special friction formulas that assure dependable stopping power, non-fading performance and extra long life.

World Bestos offers extensive research and development facilities and more than 30 years' specialization in friction material manufacture. Modern, high-capacity plant assures on-schedule delivery.

● **Write for new Industrial Brake Folder . . . or let us know your specific requirements. Send prints and specifications if possible. Engineering assistance available.**

WORLD BESTOS NEW CASTLE INDIANA

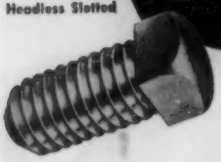
DIVISION OF THE **Firestone** TIRE & RUBBER CO.

Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

design, purchasing, production men . . .

here's why you're right with MOORE SET SCREWS

Headless Slotted



Square Head

Socket Head

Design — there's a Moore Set Screw exactly right to meet your specs. On new developments or on hard-to-solve problems we have experienced men to supply the answers.

Purchasing — you can depend on us, without question, to meet your schedules. Your reputation is backed up by our reputation of 80 years of dependable service.

Production — our inspection guarantees conformity and uniformity. Your assembly lines run smoothly and quality control is simplified.

Moore Set Screws simplify design, purchasing, production. Send for detailed price catalog.

MOORE SET SCREWS

George W. Moore, Inc.
since 1880
92 Beaver St., Waltham 54, Mass.

CIRCLE 211 ON READER SERVICE CARD

Wilbow

MOLDED RUBBER SOLVES UNUSUAL DESIGN PROBLEMS

This special "dual gasket," molded by WILBOW for Joslyn Bell Joint Clamps, assures more effective permanent sealing.

To produce a gasket that combined the quick sealing action of soft Neoprene with the strength and stability of a harder GR-S material, Joslyn engineers called on WILBOW. The unique one-piece, dual material gasket that resulted enables the Joslyn Bell Joint Clamp to seal effectively at lower torque while assuring permanently high joint packing presure.

WILBOW specializes in meeting unusual molded rubber needs with a full line of compounds including the latest synthetic, natural and silicone polymers. Let WILBOW engineers analyze your mechanical rubber requirements or send for the WILBOW catalog. Write today.

Wilbow

The WILLIAMS-BOWMAN RUBBER Co.
1935 South 54th Avenue • Cicero 50, Illinois • (Chicago Suburb)
Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

CIRCLE 212 ON READER SERVICE CARD

CAN YOU USE THIS

GIANT

UNIVERSAL DRIVE?

2,000 hp/1,000 rpm.

Koelling engineers developed the first heavy duty universal drives to connect oilfield mud pumps with powerful engines. Proved by 3 years world wide service, the principles have been incorporated into Torq-Ring Model 500, an industrial universal drive. This new Koelling drive is now available to all industries with special universal drive problems.

KOELLING TORQ-RING FEATURES

1. *Double raced bearing eliminates wear on yoke.*
2. *Open end bearing design, self purging when lubricated.*
3. *Positive mechanical blocks prevent incorrect field assembly.*
4. *Eight inch sliding spline speeds installation and allows for machinery adjustment.*
5. *Choice of flange connection to customer needs.*

Write or call today for engineering information.

KOELLING UNIVERSAL JOINTS, INC.
5526 Dyer Street • Dallas 6, Texas

A MAJOR BREAKTHROUGH ON ENGINEERING

CAMS

by the world's leading **CAM** manufacturer

Write for Bulletin No. 105
which completely details and outlines
how you can

SAVE 2,300%
on engineering computation alone

EONIC Inc. | automated CAM engineering

464 E. Hollywood Ave. • Detroit 3, Michigan

CIRCLE 213 ON READER SERVICE CARD

CIRCLE 82 ON READER SERVICE CARD

MARINE DESIGN MANUAL

FOR FIBERGLASS REINFORCED PRODUCTS

Just Published. Covers the best modern structural plastics design techniques applied to military, commercial, and pleasure craft construction. Boat hull design, materials and molding methods, engineering properties and design of laminates are among the subjects discussed. Helps you avoid trouble spots such as hard spots, stress concentrations, and knife-edge crossings. **By Engineers of Gibbs & Cox, Inc. 376 pp., 202 illus., $15.00**

THEORY OF PLATES AND SHELLS

A revised edition of a useful guide for designers working with plates and shells. Covers the general theory of bending of plates under lateral load, with applications to circular and rectangular plates, and with numerous tables simplifying the calculation of deflections and stresses in plates. Also covers the theory of bending of shells, with applications to cylindrical and spherical shells. **By Stephen Timoshenko, formerly Stanford Univ.; and S. E. Woinowsky-Krieger, Univ. Laval. 2nd Ed., 580 pp., 280 illus., $15.00**

OIL HYDRAULIC POWER AND ITS INDUSTRIAL APPLICATIONS

JUST PUBLISHED. Gives complete coverage of oil hydraulic power—how it is generated, utilized, transmitted, controlled, and applied in industry. It gives engineers and designers a full understanding of oil hydraulics as it covers the entire field from basic fluid mechanics, through component and circuit design, to the latest data on commercial equipment and hints for operation and maintenance. **By Walter Ernst, Commonwealth Engineering Co. of Ohio. 2nd Ed. 466 pp., 350 illus., 29 tables, $12.50**

DIMENSIONAL CONTROL IN PRECISION MANUFACTURING

Thoroughly covers principles and techniques of dimensional control as applied in production machining to increase production and reduce unit costs. Stresses importance of detailed planning in preparing parts for production. Shows application of machining principles and their attendant dimensional controls as well as development of a production process from the engineering standpoint. **By John L. Gadzala, Boeing Airplane Company. 205 pp., 156 illus., $7.50**

SEE THESE BOOKS 10 DAYS FREE

McGRAW-HILL BOOK CO., INC., Dept. PE-6-6
327 W. 41st St., New York 36, N. Y.

Send me book(s) checked below for 10 days' examination on approval. In 10 days I will remit for book(s) I keep plus few cents for delivery costs, and return unwanted book(s) postpaid. (We pay delivery costs if you remit with this coupon—same return privilege.)

- ☐ Gibbs & Cox, Inc.—**Marine Design Manual, $15.00**
- ☐ Timoshenko & Woinowsky-Krieger—**Theory of Plates & Shells, $15.00**
- ☐ Ernst—**Oil Hydraulic Power, $12.50**
- ☐ Gadzala—**Dimen. Control in Precision Mfg., $7.50**

(PRINT)

Name .....

Address .....

City .....Zone ....State .....

Company .....

Position .....

For price and terms outside U.S. write McGraw-Hill Int'l., N. Y. C. **PE-6-6**

PATENT SUBCLASSES— a rich vein of free ideas

Too many good ideas molder away in the Patent Office files. Here are some thoughts on how these ideas might better be mined. They come from an article by Heinrich von Wimmersperg in the March *Journal of the Patent Office Society*.

"Many conditions besides technical merit determine the industrial success of an invention. Some of the most important inventions came too early, at a time when technical links were missing. Some did not find a promoter with vision enough to stick through the difficult process of converting ideas into products. Others were just as good as parallel solutions in public use, but did not find their way to production. All this invisible creative thinking is preserved in the patents. Furthermore, patents give the most complete information on products that did reach production. Thus the patents cover almost the total of the important creative technical thinking of a nation.

"Copies of the patents, filed in numerical order, are kept in the public libraries of many cities. They are of great value as reference for a specific patent, but they are of no practical value for the development engineer who needs fast and complete information on all technical elements and element groups concerning his assignment. He needs the patents filed according to subclasses and elementary groups. It is true he can obtain from the Patent Office in three weeks the patent numbers of the various classes, but to take several hundreds of volumes out from the shelves and then to find the patents in the volumes takes weeks and even months. I have tried it. Never again.

"The subclasses are the most comprehensive textbooks. They show the historical development, the reasons for failure, the ways to overcome failure, the new trends in development; they show millions of technical solutions, most of them free to public use. They show the property rights to be respected. Therefore, the development engineer should have this textbook always at his fingertip, ready for consultation, ready to thumb through, freeing his mind for the new problem, avoiding the re-creation of old inventions over and over, making him ready for new approaches by showing the

continued on page 85

FREE!

416-PAGE **PIC MASTER CATALOG #21**

Lists over 12,000

PRECISION INSTRUMENT PARTS and ASSOCIATED COMPONENTS

Available From STOCK!

GEARS • SHAFTS • COLLARS • CLUTCHES • BEARINGS • COUPLINGS • DIFFERENTIALS • SPEED REDUCERS and many other Precision Engineered Parts & Components.

Send For Your Copy Today.

PIC DESIGN CORP.

Subsidiary of **BENRUS WATCH COMPANY, Inc.**

47-29 Atlantic Ave., East Rockaway, L.I., N.Y.

CIRCLE 215 ON READER SERVICE CARD

Strataflo

SPECIAL **CHECK VALVES** for Submersible Pumps

SILICONE TREATED RUBBER POPPET

Tapped one or two holes for attaching Pressure Switch, Pressure Gauge or Snifter Valve.

No. 350

Here's the answer to your Check Valve problems on submersible pumps. The taper-type rubber poppet is noiseless, does not leak, opens easily. Works in any position.

All bronze body. Five sizes, ⅜" through 2". May be tapped for one or two side connections as shown. Used as original equipment by many leading pump manufacturers.

Write today for Bulletin 203, or telephone Harrison 3313 for more information.

STRATAFLO PRODUCTS, INC.
FORT WAYNE, INDIANA

CIRCLE 83 ON READER SERVICE CARD

In Checking Surface Roughness

In judging microinch roughness by eye or by "feel," sometimes you'll get the right answer, and sometimes not. *You can never be SURE;* for the "confusion factors" are many, and the brain misinterprets what the senses report — the same as with optical illusions.

That's one reason why industry depends on a confusion-proof *shop instrument*—the PROFILOMETER®—when dependable roughness measurements are required.

FREE BULLETIN LT1 shows why surfaces that look alike, or feel alike, often differ in roughness by several hundred percent. *Write for it!* You'll be interested, and perhaps surprised.

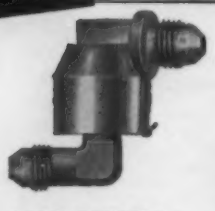
Profilometer is a registered trade-mark.

MICROMETRICAL
MANUFACTURING COMPANY

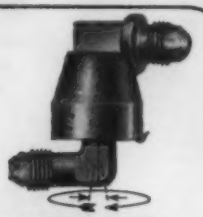
345 S. MAIN ST. ANN ARBOR 5, MICHIGAN

CIRCLE 215 ON READER SERVICE CARD

NOW AIRCRAFT TYPE SWIVEL JOINTS



LOW TORQUE PLANE SWIVEL JOINT— 360° rotation in a single fixed plane.



NEW SELF-ALIGNING SWIVEL JOINT— 360° rotation *plus* 15° side flexibility.

BARCO Offers Two Standard Types

Here are the newest designs in the field! SEND TODAY FOR BARCO CATALOG 269A. Since 1941 Barco Swivel Joints and special Flexible Assemblies have met the precise requirements of in-flight and other types of military equipment . . . *conforming to MIL-J-5513A and other specifications.* Barco's wide experience is yours to call upon in the development of your particular project — aircraft, missile, track vehicle or special installation — for hydraulic, pneumatic, oxygen, fuel, gas or liquid service. Barco Representatives are at your service in the specification of standard or specialized adaptations of standard designs.

BARCO MANUFACTURING CO.
5270 N. Hough Street • Barrington, Illinois

Serving Industry Since 1908

CIRCLE 216 ON READER SERVICE CARD

Standard *For* Industry

CENTURY Liquid Level SIGHT GAGES

- **Easiest Possible Installation on any wall thickness**
- **Large Face for Better Visibility— 7" Overall**
- **Can be used with non-inflammable oil**
- **Leak-Proof — No Dripping**
- **For Better Service at Lower Costs, Start Using Century Gages Today**
- **Available Immediately — from STOCK**

Send for new catalog containing dimensional information on hydraulic reservoirs and complete line of power unit accessories.

CENTURY HYDRAULICS
Division of CENTURY-DETROIT
6101 Concord Ave. • Detroit 11, Mich.
Telephone: WAlnut 3-8088

USE THE READERS' SERVICE CARD

for:

additional product information

copies of catalogs & bulletins

multitude of the old efforts.

"When a complex machine or instrument is to be developed, let us assume a machine gun or a photographic camera, not only the many subclasses directly related to the field are important, but also very many other more general classes, like clutches, ratchets, fastening methods, ways of avoiding rebound, buffers, etc.

"It is true that many manufacturers keep a collection of patents pertinent to their field. But these patents are mostly for the use of the patent counsel of the company, to find out whether the work already done by the engineer would involve protected or protectable ideas. There, the patent is a weapon for defense, but not a tool for production, as originally intended, and as it is in some countries.

"The present trial-and-error method of developing a new product is wasting time, money and talents. The engineer has to start work without complete knowledge of prior art of his or of the related fields. Maybe there is a solution, described in an early patent, which would fit exactly to the new combination, and which is free to public use. But he does not know it, so he spends much time finding it by himself. Maybe the whole idea is old. He works months and even years, making models, and conducting experiments. Then, when his idea works, the patent counsel suggests a search. After several weeks the agent in Washington finds the prior art. All the time, money and energy was wasted. If the agent overlooks the prior art, a patent will be filed, and after a year or so the prior art might be found in the action of the Patent Office. More time, more money wasted. If the engineer had the op-

continued on page 86

"How's that for a perpendicular?"

How United States Testing Company helps

MAKE A GOOD PRODUCT BETTER

Peak performance, structural soundness, styling that "sells"...that's design know-how which gives you the margin over your competitors. We measure that margin for you at United States Testing Company ...and often increase it. Take the case of the prototype vacuum cleaner sent in for a complete evaluation:

Dirt disappeared like magic... impact resistance of the plastic parts proved very good...the metal case resisted impact and corrosion. So far...so good.

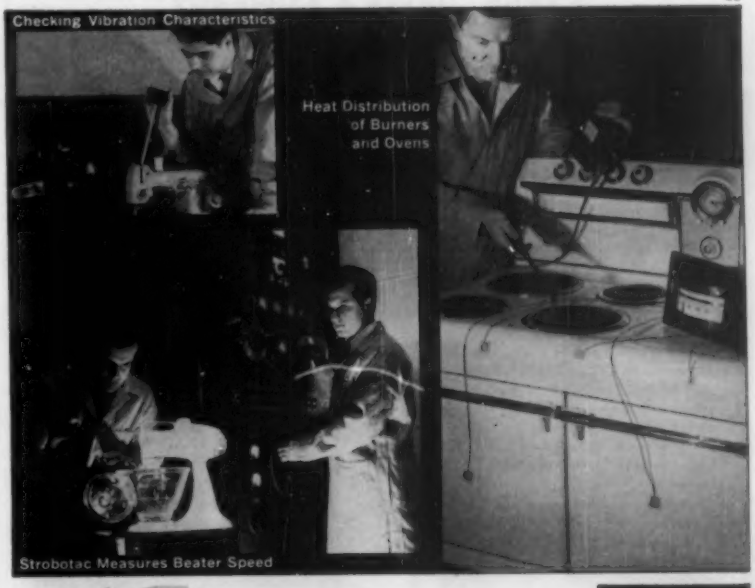
Then we measured consumer acceptance, using a panel of housewives:

Too heavy...too hard to maneuver... uncomfortably noisy...wrong color. But we had the solution.

Our report to the client specified newer, lighter materials, sound deadening, and appealing colors. Retest of the improved model warranted production go-ahead.

Why not let United States Testing Company measure, and increase, the competitive margin of your product? Write or phone for details.

15



Send for free bulletin describing our evaluation and R/D services

The World's Most Diversified Independent Laboratory.

United States Testing Co., Inc.
1415 Park Avenue, Hoboken, N. J.

Branch Laboratories BOSTON • BROWNSVILLE • DALLAS • DENVER • LOS ANGELES MEMPHIS • NEW YORK • PHILADELPHIA • TULSA

CIRCLE 85 ON READER SERVICE CARD 85

EMPLOYMENT OPPORTUNITIES

NATIONAL COVERAGE

DISPLAYED —RATES— UNDISPLAYED

The advertising rate is $37.00 per inch, effective Jan. 1960, for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on a column—3 columns, 30 inches to a page.

Subject to Agency Commission.

$2.10 per line, minimum 3 lines. To figure payment count 5 average words as a line. Box numbers—counts as 1 line.

Position Wanted ads, ½ of above rate. Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not Subject to Agency Commission.

Send NEW ADS and Inquiries to Classified Adv. Division of Product Engineering, P.O. Box 12, N.Y. 36, N.Y.

SENIOR DESIGN ENGINEER

B.S.M.E. or B.S.E.E. to work in the design and development of electric clocks. At least five years of electro-mechanical design experience required.

Send resume to:

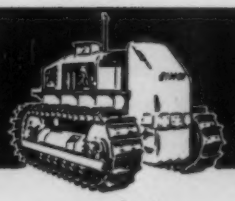
W. P. ENGELKING
Technical Personnel Director
SUNBEAM CORPORATION
5600 W. Roosevelt Road, Chicago 50, Illinois

PACKAGING MACHINE DEVELOPMENT

AN OPPORTUNITY FOR A GRADUATE ENGINEER WITH SEVERAL YEARS EXPERIENCE IN DESIGN AND DEVELOPMENT OF SPECIAL MACHINES

PERSONNEL DEPARTMENT

PARKE, DAVIS & COMPANY
Detroit 32, Michigan



MECHANICAL DESIGN ENGINEERS

Earthmoving experience, with successful record in design and development of heavy mechanical equipment, crawler tractors, bulldozers, winches and tractor attachments.

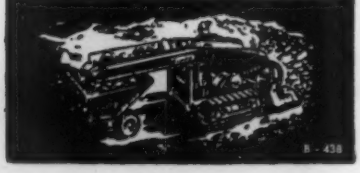
Work includes layout and design of heavy machinery for construction and mining.

Permanent position open, for those qualified, with one of the nation's fastest growing heavy machinery manufacturers.

Location—Salt Lake City, Utah—in the mountain West, where you can breathe clean air, and drive from home to work in less than 20 minutes.

Send Complete Information and photograph to Dept. SXB

THE EIMCO CORPORATION
P. O. Box 300, Salt Lake City 10, Utah



FOR INFORMATION

ABOUT CLASSIFIED ADVERTISING

Contact The McGraw-Hill Office Nearest You

ATLANTA, 3
1301 Rhodes-Haverty Bldg. *JAckson 3-6951*
M. MILLER

BOSTON, 16
350 Park Square *HUbbard 2-7160*
M. J. HOSMER

CHICAGO, 11
520 No. Michigan Ave. *MOhawk 4-5800*
W. J. HIGGENS

CLEVELAND, 13
1164 Illuminating Bldg. *SUperior 1-7000*
W. B. SULLIVAN

DALLAS, 2
1712 Commerce St., Vaughan Bldg. *RIverside 7-5117*
GORDON JONES - F. E. HOLLAND

DENVER, 2
1700 Broadway, Tower Bldg. *ALpine 5-2981*
J. PATTEN

DETROIT, 26
856 Penobscot Bldg. *WOodward 2-1793*
J. R. PIERCE

LOS ANGELES, 17
1125 W. 6 St. *HUntley 2-5450*
W. C. GRIES

NEW YORK, 36
500 Fifth Ave. *OXford 5-5959*
H. T. BUCHANAN - R. P. LAWLESS
T. W. BENDER

PHILADELPIA, 3
Six Penn Center Plaza *LOcust 8-4330*
H. W. BOZARTH - H. NICHOLSON

PITTSBURGH, 22
1111 Oliver Bldg. *EXpress 1-1314*
P. PIERCE

ST. LOUIS, 8
3615 Olive St. *JEfferson 5-4867*

SAN FRANCISCO, 4
68 Post St. *DOuglas 2-4600*
S. HUBBARD

portunity of thumbing through the subclasses he would find in few hours what is old and free in this field, what is old but still protected, and where he can get a patent himself.

"In spite of the importance of this textbook there is one place only in the entire United States where it can be read—in Washington at the Patent Office. In realization of the importance of the patent classes, the British Patent Office printed them in abridged form for a good many years in separate volumes, each covering a five-year period. In Germany, many industrial cities make the subclasses available in the public library.

"The European practice of reducing patent drawings to a minimum of structural details makes it easier for experts to understand the actual new conception and to separate it from old art without the help of a description. Therefore, it might be a step forward to make the drawings of foreign patent subclasses available to the US engineer. In order to avoid infringement of valid corresponding US patents he can easily find out whether a specific patent has a US counterpart. If not, he is free to use it if the product made in the US is not to be exported to a country where the invention is patented.

"Modern microfilming could be a way to convenient distribution of the subclasses to the public libraries in industrial cities. Further, it might be possible to sell the rolls of the subclasses to engineering groups. This would cost less than frequent patent searches and would have considerable advantages, saving time and cost in the early engineering stage; avoiding legal battles later."

The West is involved in a hard, bitter struggle to stay ahead industrially. The East is making astonishing and alarming progress. Its engineering capacity symbolized by the number of graduating engineers is growing faster than that of the West. Therefore it is most important for us to make efficient use of our engineering capacity in order to stay competitive. It is true we spend billions for research laboratories and more billions for production. But the development engineer, the link between research and production, is deprived of his best tool, patent subclasses. The patent, instead of being the teacher of the nation, is reduced to a mere fence, often quite a low fence, for short-lived monopolies. ■

REPRINTS

As long as the supply lasts, readers in US and Canada can secure one copy of "P" lettered reprints, without charge, by using one of the Reader Service cards bound inside the back cover. Note that the card must be used within 60 days of publication date.

Belt Drives ..... P 53
Selecting the Right Solenoid ..... P 52
Pneumatics Simulate Electronics P 51
Wear Life of Rolling Surfaces .... P 50
Electrical Analogs Simplify Heat-flow Analysis ..... P 49
Shaping Vulcanized Fibre Parts .. P 48
Centralized Lubrication ..... P 47
Integral Ballbearings ..... P 46
3-D Harness Wiring ..... P 45
Standards for Metal Hose ..... P 44
Marking Your Part ..... P 43
7 Steps to Better Oral Reporting .. P 42
Best Results with Printed Wiring . P 41
Elliptical Gears ..... P 40
Variable-Speed Motor Drive ..... P 39
Faster Ways to Set Statistical Tolerances ..... P 38
4 Types of Vibrators ..... P 37
Resin-Bonded Wood Compositions P 36
20 Applications for Screw Threads P 35
Integrally Sealed Ballbearings .... P 34

QUANTITY PRICES

For single shipments of any one title to one address on order accompanied by remittance, quantity orders will be supplied as long as the supply lasts:

Quantity	Price per copy
5	$0.25
25	0.20
50	0.20
100	Write for quotation

Make checks payable to PRODUCT ENGINEERING, 330 West 42nd St., New York City 36, N. Y.

SPECIAL REPORTS

Here is a list of special reports still available. You may obtain them by writing Reader Service Dept., PRODUCT ENGINEERING, 330 W 42 St., New York 36. Please enclose remittance with order; we pay postage.

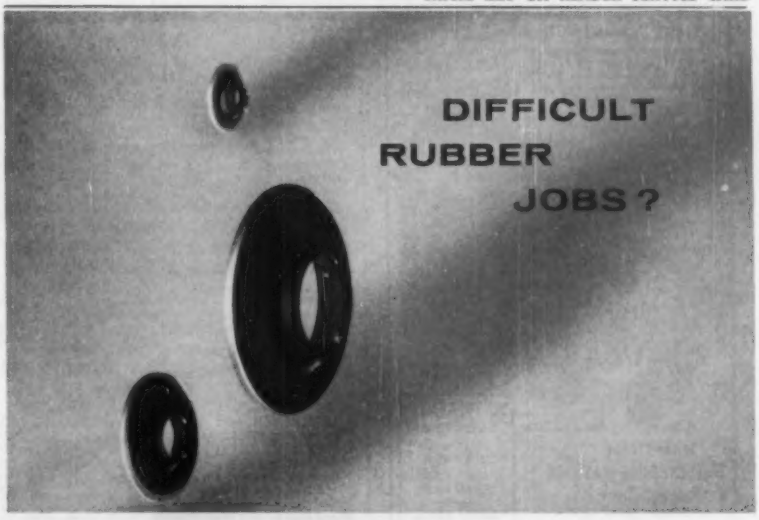
Magnesium Finishes (25¢) ..... R 50
Positive-Displacement Pumps (25¢) ..... R 49
Reinforced Plastics (60 p $2) .... R 48
Fastening Gears to Shafts ..... R 47
Manual for Reliability (32 p 50¢) ..... R 46
Stress Analysis of Combinel Loads on Beams (25¢) ..... R 45
Aluminum Diecastings (25¢) ..... R 44
The Rare Earth Metals (25¢) .... R 43
Hand Lay-Up (25¢) ..... R 42
Design by Digital Computer (16 p; 50¢) ..... R 41
Four Bar Linkages (11 p; 50¢ .... R 40
Air Preforming with Matched-metal Dies (25¢) ..... R 39
New Equations for Circular-arc Cams (25¢) ..... R 38

INSIDE STORY

THE INSIDE STORY ON BAILEY HYDRAULIC TACHOMETERS. As shown on cut-away view above, **VIKING PUMPS** are built inside, as integral parts of Bailey hydraulic tachometers, manufactured by Bailey Meter Company of Cleveland, Ohio. They're part of closed-loop speed governing systems used on such equipment as fans, stokers, pumps and feeders driven by variable speed motors, engines and turbines. Pumps are submerged in oil and deliver variable amounts under pressures up to 30 PSI. If you need positive displacement pumps to fit equipment, specify **VIKINGS.** Inside Bailey tachometers, they have proved reliable over the years in hundreds of applications installed all over the world. You can rely on them, too. **VIKING** sizes range from ½ to 1050 GPM, in hundreds of stock models and thousands of special arrangements. For information, write for catalog BX. **VIKING PUMP COMPANY,** Cedar Falls, Iowa, U.S.A. In Canada, It's **"ROTO-KING" PUMPS.**

See Our Catalog In Sweet's Product Design File

CIRCLE 220 ON READER SERVICE CARD



THAT'S OUR "CUP-OF-TEA" AT STONER! We take the tough jobs other companies won't do or can't do! Our team of Rubber Chemists and Production Engineers **like the challenge** of helping you solve your problems. Maybe **you** have a close tolerance job; barrier problem; bonding problem, etc. **We invite your blueprints for quotation or recommendation.**

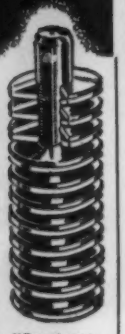
Write for our new 24 page illustrated catalog

STONER RUBBER COMPANY, INC.
10792 Knott Ave., Anaheim, California
A subsidiary of **CARLISLE CORPORATION**

REPRESENTATIVES **PHOENIX** Howe & Howe, 4328 North 42nd Place; **DALLAS** L. M. Harris, P.O. Box 5936, Terminal Annex Bldg.; **SEATTLE** J. S. Barlow, Northwest Plastics, 1220 East Cherry

CIRCLE 87 ON READER SERVICE CARD

SCHNORR
Disc Springs



ELIMINATE:
FATIGUE
SETTLING
CREEPING

SCHNORR SPRINGS PROVIDE UNLIMITED LIFE!

Check these exclusive features:

- **ADJUSTMENT**— SCHNORR SPRINGS provide different pressure and deflection with exacting adjustment. ALL FROM ONE SIZE.
- **COMPACTNESS**— Great power is concentrated in a very small space.
- **ABSORPTION**— Dampens impacts and minimizes after-oscillation.
- **VERSATILITY**— SCHNORR SPRINGS can be easily adjusted to provide a varied range of spring pressures and deflections. The springs may also be stacked to provide multiple force.
- **SPECIALIZATION**— SCHNORR DISC SPRINGS may be obtained in a variety of sizes for specialized tasks. MODEL K is especially adaptable to eliminate noise and play in ball bearings.

Further information and Literature on SCHNORR DISC SPRINGS is available from:

Exclusive Distributor *ONE OF MANY*

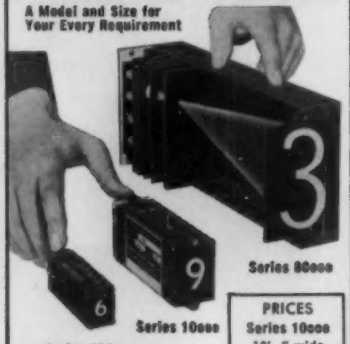
KARL A. NEISE, INC.
Dept. PE-20, 404 4th Ave.
New York 16, N. Y.

NEISE MODERN TOOLS

CIRCLE 219 ON READER SERVICE CARD

Proven, Dependable, Rear-Projection Type
IN-LINE DIGITAL DISPLAYS

A Model and Size for Your Every Requirement



Series 80000
Series 10000
Series 120000

OUTSTANDING FEATURES

- All digits displayed on front viewing screen
- All digits uniform in size and intensity
- High-contrast viewing screen
- Digit style of your choice
- Colored digits of your choice
- Individual units may be group assembled for panel mounting

WRITE TODAY FOR COMPLETE SPECIFICATIONS
Representatives in principal cities

PRICES

Series 10000
1 1/16" wide
2 3/8" high
5 3/8" long
$18.00 each

Series 80000
3 1/4" wide
5 1/4" high
11 5/16" long
$33.00 each

Series 120000
1" wide
1 5/16" high
3 7/8" long
$35.00 each

Quantity Prices On Request

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 Vineland Avenue,
North Hollywood, Calif.

INDEX OF PRODUCTS
ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD

A

Actuators
  Mechanical 68
Assemblies
  Structural 16
Axles 77, 78

B

Bars
  Metal 9
Bearings
  Ball 5, 28, 57, 63, 66, 73
  Needle 57, 73
  Roller 57, 73
  Self-Lubricating 80
Books 83
Brass 61

C

Cams 82
Control Panels & Switchboards 88
Controls
  Electrical ..... 4th Cover
  Electronic ..... 4th Cover
  Hydraulic 67
  Mechanical 67
  Pneumatic 11, 67
Couplings
  Hose 30
  Tube 30
Cylinders
  Hydraulic 67
  Pneumatic 11, 67

D

Deep Drawing 14
Die Castings 65
Drafting
  Machines 70-71
  Supplies 70-71
Drives
  Mechanical 7, 82
  Right-Angle 80
  Variable Speed 90

E

Enclosures 72
Engineering Services (see also Production Services) 85
Engines 59

F

Facings, Clutch 81
Fastening Methods 16, 27
Fibre 12
Film, Plastic 52
Fittings, Hose, Pipe & Tube 13, 15, 30
Flexible Couplings 72
Friction Materials 81
Furniture, Engrg. Dept. 70-71

G

Gages 84
Gears 70, 79, 90

H

Hose & Tubing 30
Hydraulic Fluids 69

I

Instruments
  Mechanical 83, 84

J

Joints
  Swing & Swivel 84
  Universal 7, 82

L

Lamps, Indicator 60
Laminated Plastics (see Plastics, Laminated)
Linings, Brake 81
Liquid Level Controls 84
Lubricants 69
Lubricating Equipment ..... 2nd Cover

M

Metal Forming 14
Moldings
  Plastics (see Plastic Parts)
  Rubber (see Rubber Parts)

N

Nickel Alloys 54

P

Packings 64
Photographic Equipment
  Film 52
Plastic Parts 80
Plastics 25-26, 62-63
Plastics Laminated 12
Plugs 74
Printed Circuits 78
Production Services (see also Engineering Services) 85
Pumps
  Liquid 87

R

Resins 25-26
Revolving Joints (see Joints, Swing & Swivel)
Rod Ends 5, 63
Rubber ..... 3rd Cover, 268
Rubber Parts ..... 3rd Cover, 87

S

Screws 82
Screw Thread Inserts 72
Seals 13, 64
Silicone Rubber ..... 3rd Cover
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) 27
Speed Increasers & Reducers 90
Spinning 14
Splines 68
Springs 88
Steel
  Alloy 78
  Stainless 75
  Tool 78
Strip, Metallic 61
Switches ..... 4th Cover

T

Thermostats 2
Transmissions 80
Tubes 89
Tubing
  Welded 89

V

Valves
  Air 11, 67, 70
  Hydraulic 67, 83
  Solenoid 11

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

A

Allegheny Ludlum Steel Corp..... 75
AllenAir Corp. 70
Anchor Coupling Co., Inc..... 15

B

Barco Mfg. Co. 84
Beaver Precision Products, Inc..... 68

C

Century Hydraulics, Inc. 84
Cincinnati Gear Co. 79
Cutler-Hammer, Inc. .....4th Cover

D

du Pont de Nemours & Co., (Inc.), E. I., Film Dept. 52
du Pont de Nemours & Co., (Inc.), E. I., Polychemicals Dept. 25-26

E

Eonic, Inc. 82

F

Farval Div., Eaton Mfg. Co.....2nd Cover
Formed Tubes, Inc. 89
Funk Mfg. Co. 80

G

General Electric Co., Miniature Lamp Dept. 60
Grace & Co., W. R., Polymer Chemicals Div. 62-63

H

Hamilton Mfg. Co., Drafting Equipment Div. 70-71
Helm Co. 5

I

Imperial Brass Mfg. Co..... 13
Industrial Electronic Engineers, Inc. 88
Industrial Tectonics, Inc..... 73
International Harvester Co., Construction Equipment Div..... 59
International Nickel Co., Inc..... 54
Invo Spline, Inc. 70

K

Kaupp & Sons, C. B. 14
Kaydon Engineering Corp..... 57
Koelling Universal Joints, Inc..... 82

L

LaSalle Steel Co..... 9
Linear, Inc. 64
Lisle Corp. 74
Logansport Machine Co., Inc..... 67

M

MacDermid, Inc. 78
McGraw-Hill Book Co., Inc..... 83
Madison-Kipp Corp. 65
Micromatic Home Corp., Micro-Precision Div. 80
Micrometrical Mfg. Co..... 84
Minnesota Rubber Co. .....3rd Cover
Moore, Inc., George W..... 82

N

Neise, Karl A..... 88
New Departure Div., General Motors Corp. 28
New Hampshire Ball Bearings, Inc... 66

P

PIC Design Corp..... 83
Patent Button Co. of Tennessee, Inc. 80
Peninsular Steel Co. 78
Philadelphia Gear Corp..... 90
Prior Products, Inc..... 78

R

Revere Copper & Brass, Inc..... 61
Rockwell-Standard Corp., Transmission & Axle Div..... 77
Rockwell-Standard Corp., Universal Joint Div. 7
Rosan, Inc. 72

S

Schrader's Son, A., Div., Scovill Mfg. Co., Inc. 11
Shell Oil Co. 69
South Chester Corp., Southco Div... 27
Stephens-Adamson Mfg. Co., Spherco Bearings & Rod Ends Div.. 63
Stevens Mfg. Co., Inc..... 2
Stewart-Warner Corp., Alemite Div.. 30
Stoner Rubber Co..... 87
Stratoflo Products, Inc..... 83

T

T A Mfg. Corp. 72
Taylor Fibre Co. 12
Thomas Flexible Coupling Co.*..... 72

U

Unistrut Products Co., Rotocon Div.. 16
U. S. Testing Co., Inc..... 85

V

Viking Pump Co..... 87

W

Williams-Bowman Rubber Co..... 82
World Bestos Corp., Div., Firestone Tire & Rubber Co..... 81

PHILIP G WEATHERBY *advertising sales manager*
P F PRITCHARD *manager, market development*
THOMAS R COASH *circulation*
RUSSELL T DOUGLAS *business manager*

ADVERTISING SALES STAFF

ATLANTA 3 . . . W. O. Crank, 1301 Rhodes-Haverty Bldg, Jackson 3-6951
BOSTON 16 . . . M. A. Williamson, Jr., 350 Park Square Bldg, Hubbard 2-7160
CHICAGO 11 . . . Mid-Western Adv Sales Manager, A. E. Meanor; R. W. Bruley, L. Anderson, 520 N Michigan Ave, Mohawk 4-5800
CLEVELAND 13 . . . A. F. Tischer, 1164 Illuminating Bldg, 55 Public Sq, Superior 1-7000
DALLAS 1 . . . John Grant, 901 Vaughn Bldg, 1712 Commerce St, Riverside 7-5117
DENVER 2 . . . John W. Patten, Tower Bldg, 1700 Broadway, Alpine 5-2981
DETROIT 26 . . . P. B. Robinson, 856 Penobscot Bldg, Woodward 2-1793
HOUSTON 25 . . . Gene Holland W-724, Prudential Bldg., Jackson 6-1281
LOS ANGELES 17 . . . Robert Obenour, 1125 West 6th St, Huntley 2-5450
NEW YORK 36 . . . B. K. Adams, F. J. McKinley, 500 Fifth Ave, Oxford 5-5959
PHILADELPHIA 3 . . . D. G. Jones, K. S. Willadson, 6 Penn Center Plaza, Locust 8-4330
PITTSBURGH 22 . . . C. F. Leveroni, 1111 Oliver Bldg, Express 1-1314
ST LOUIS 8 . . . R. W. Bruley, 3615 Olive St, Continental Bldg, Jefferson 5-4867
SAN FRANCISCO 4 . . . W. C. Woolston, 68 Post St, Douglas 2-4600

SUBSCRIPTIONS. Send subscription correspondence and change of address to Fulfillment Manager, PRODUCT ENGINEERING, 330 W 42nd St, New York 36, NY. Subscribers should notify Fulfillment Manager promptly of any change of address including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance, please allow one month for change of address to become effective. Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connection must be indicated on subscription orders.

OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.
EMPLOYMENT OPPORTUNITIES..... 86

Index to Advertisers appears on P. 89
Products Index appears on P. 88

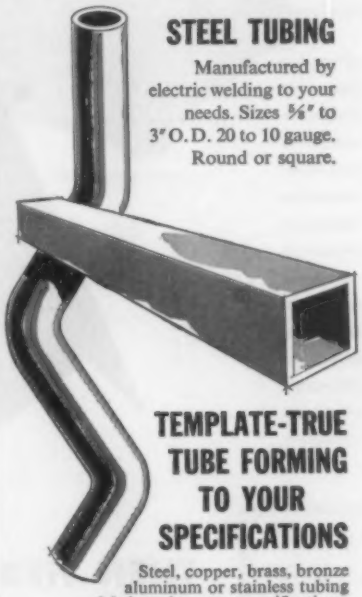
NOW
TWO
FORMED
TUBES
PLANTS
to serve you

1. Sturgis, Michigan

In heart of metal working industry.
Seven large truck line terminals.
New York Central and
Pennsylvania Railroads.

2. Haleyville, Alabama

Convenient to Birmingham.
On U. S. Highway 278.
Southern and Illinois Central Railroads.



STEEL TUBING

Manufactured by electric welding to your needs. Sizes ⅝" to 3" O.D. 20 to 10 gauge. Round or square.

TEMPLATE-TRUE TUBE FORMING TO YOUR SPECIFICATIONS

Steel, copper, brass, bronze aluminum or stainless tubing fabricated to your specifications. Sizes ⅝" to 6" OD, 20 to 10 gauge.

Thirty-four years of experience in forming, welding, beading, bending, stamping of formed tubes.

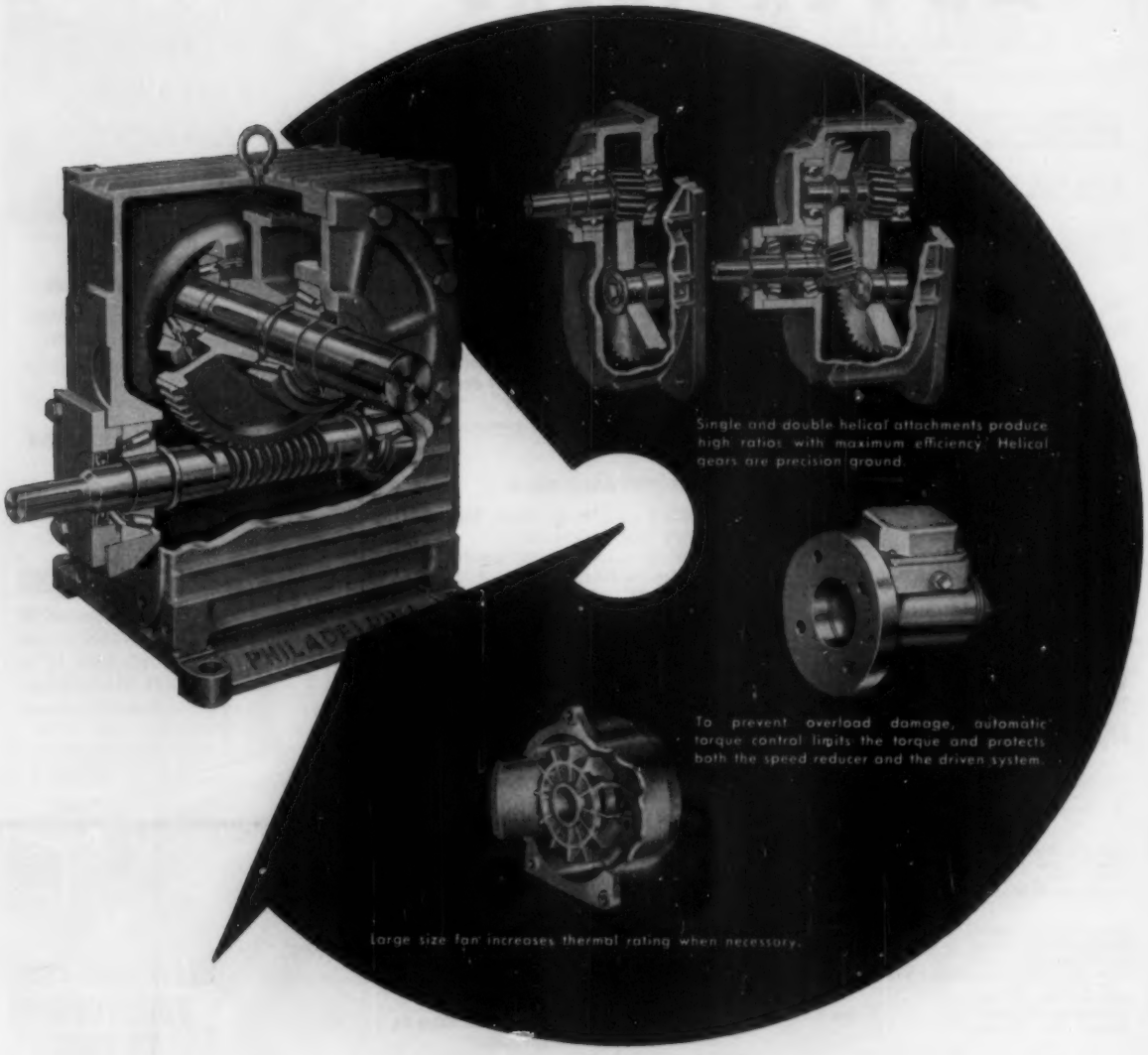
Top-flight engineering service.

Write, wire or phone for booklet or quotation.

Formed Tubes, Inc.
607 Prairie Street, Sturgis, Michigan

Formed Tubes, INC.

Want higher worm gear efficiency?


Single and double helical attachments produce high ratios with maximum efficiency. Helical gears are precision ground.
To prevent overload damage, automatic torque control limits the torque and protects both the speed reducer and the driven system.
Large size fan increases thermal rating when necessary.

THEN HERE IT IS... FROM PHILADELPHIA

Here's new high efficiency in heavy duty worm gear drives that has never been available before. Helical attachments for double and triple reduction units combine the efficiency advantage of helical gearing with the high ratio advantage of worm gearing. You save on power... operating temperatures are lower... gearing lasts longer.

New high capacity, too. Improved tooth forms, precision ground alloy steel worms, special high strength bronze gears, heavy duty housings, precision ground helical gearing ... all add up to higher capacity in less space. In many instances you can save up to 50% in space, 40% in weight.

Delivery from stock of any drive arrangement and any mounting arrangement. Ratios from 5⅓:1 to 6150:1. Center distances: 3 in. to 21 in. Torque control attachments are also available from stock. For complete data, write for catalog WG-60.

philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Prussia, Pennsylvania (Suburban Philadelphia)

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

PERSONAL READER SERVICE

USE ATTACHED CARDS FOR PERSONAL COPIES OF ADDITIONAL PRODUCT DESIGN DATA

. . . Data on Materials and Components
. . . Free Article Reprints
. . . New Catalogs and Bulletins
. . . Brochures on Advertised Products
. . . Personal Suscriptions to PRODUCT ENGINEERING

Valuable new data on product design engineering — readily available to you — FREE.

Just circle the numbers on the request cards that are identical with the numbers printed under each Advertisement, New Product and Bulletin throughout this issue.

Reprint numbers are prefaced with the letter "P". *One free reprint* is available for each article offered.

Issue of June 6, 1960
PRODUCT ENGINEERING
Card expires August 5, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

USE THIS CARD

to be sure that you get your personal copy of the Design Digest issue mailed in mid-September.

This comes as part of every regular subscription (U.S.A.) at $3.00 per year.

This single popular issue will contain more than 600 pages of basic design information . . . organized and indexed for ready reference.

Issue of June 6, 1960
PRODUCT ENGINEERING

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

SUBSCRIPTION

22 FL

ADD TO YOUR DESIGN REFERENCE FILE FROM

EDITORIAL REPRINTS AVAILABLE

(Single reprint free — quantity prices on page 87)

P34—INTEGRALLY-SEALED BALL BEARINGS—2/29/60

P35—20 APPLICATIONS FOR SCREW THREADS—2/29/60

P36—RESIN-BONDED WOOD COMPOSITIONS—2/29/60

P37—FOUR TYPES OF VIBRATORS—3/7/60

P38—FASTER WAY YTO SET STATISTICAL TOLERANCES—3/21/60

P39—VARIABLE SPEED MOTOR DRIVE—3/28/60

P40—ELLIPTICAL GEARS—3/28/60

P41—BEST RESULTS WITH PRINTED WIRING—4/4/60

P42—7 STEPS TO BETTER ORAL REPORTING

P43—MARKING YOUR PART—4/4/60

P44—STANDARD FOR METAL HOSE—4/11/60

P45—3-D HARNESS WIRING—4/18/60

P46—INTEGRAL BALL BEARINGS—4/25/60

P47—WHEN TO SPECIFY CENTRALIZED LUBRICATION—5/2/60

P48—THESE NINE WAYS FOR SHAPING VULCANIZED FIBRE PARTS—5/2/60

P49—ELECTRICAL ANALOG SIMPLIFIES HEATFLOW ANALYSIS—5/2/60

P50—WEAR LIFE OF ROLLING SURFACES—5/9/60

P51—PNEUMATICS SIMULATES ELECTRONICS—5/9/60

P52—SELECTING THE RIGHT SOLENOID—5/23/60

P53—BELT DRIVES—5/30/60

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

*MULTIPLE Key No.	PRODUCT ADS Specific Product

REPRINTS

P34	P35	P36	P37	P38	P39	P40	P41	P42	P43
P44	P45	P46	P47	P48	P49	P50	P51	P52	P53

TAKE ADVANTAGE OF NEW LOW PRICE!

Have your own personal subscription to PRODUCT ENGINEERING sent each week to your office or home. You are then sure that you won't miss a single weekly issue. Further, each year of your subscription you will have your copy of the annual, thick Design Digest issue to read and refer to for years to come.

☐ 1 year—NOW $3 U.S. only* ☐ 2 years—NOW $4

*Canada
1 year—$5
2 years—$8

☐ Payment enclosed

☐ Bill me

Name ..... Title .....

Home ☐ .....

Address Office ☐ ..... Dept.....

City ..... Zone ..... State .....

Company Name ..... Product Mfgd.....

NEW CATALOGS AND BULLETINS

GENERAL ENGINEERING

360—Product Appearance, 6 pp, Mast Development Co Inc.

366—Lab and Testing Instruments, 16 pp, Leeds & Northrup Co.

METALS AND ALLOYS

350—Industrial Perforated Metal, 40 pp, National-Standard Co.

NON-METALLIC MATERIALS, FINISHES

353—Silicones and Their Uses, 16 pp, Dow Corning Corp.

FABRICATION PROCESSES AND PRODUCTION

354—Metal-products Facilities, 12 pp, Dow Metal Products Co.

MECHANICAL PARTS

352—Gasketing and Gaskets, 12 pp, Greene, Tweed & Co.

359—Zipper Tubing, 4 pp, Alpha Wire Corp.

364—Molded Nylon Parts, 6 pp, Nylomatic Corp.

365—U-ring, 4 pp, Greene, Tweed & Co.

FASTENING AND JOINING

367—Bonding Insulation Materials, 4 pp, Miracle Adhesives Corp.

THIS WEALTH OF VITAL INFORMATION . . .

NEW COMPONENTS

GENERAL ENGINEERING

330—Thermoelectric Experimental Kit

METALS AND ALLOYS

318—Spring Wire for 600 to 1000 F

NON-METALLIC MATERIALS, FINISHES

303—Viscoelastic Damping Compound

FABRICATION PROCESSES AND PRODUCTION

309—Magnesium Interlocking Units

POWER TRANSMISSION

301—Magnetic Rotary Steppers
305—Lightweight 10 ft-lb Clutch
319—C-flange Gearmotor
320—Heavy-duty Roller Chain
322—Spherical Roller Bearing

MECHANICAL PARTS

311—Air-actuated Impulse Counter

FASTENING AND JOINING

308—One-component Adhesive
310—High-strength Bolts

MOTORS, ENGINES AND CONTROLS

314—Open Weatherproof Ac Motor

ELECTRICAL, ELECTRONIC COMPONENTS

302—Electric Heating Elements
304—Rotary Limit Switch
313—Additional Detection Circuits
316—Transistorized Decade Counter
317—Twin-lamp Legend Lights
321—Time-utilization-meter Panel
323—High Power Switching Device
324—4PDT Slide Switch
325—Electric Counter
327—Ultrasonic Soldering Iron
328—Miniature Switch
329—Miniature Solid-state Voltage Regulator

HYDRAULIC, PNEUMATIC EQUIPMENT

300—Stainless Steel High-pressure Pump
306—Three-way 10,000 Psi Valve
307—Solenoid-operated Air Valves
312—Flow Check Snubber
315—Air-control Sleeve Valve
326—Variable-volume Pump

MOTORS, ENGINES AND CONTROLS

362—Small-engine Carburetor, 8 pp, ACF Industries Inc, Carter Carburetor Div.

ELECTRICAL, ELECTRONIC COMPONENTS

357—Circuit-breaker Load Centers, 16 pp, General Electric Co.

358—Dc Power Supplies, 16 pp, Perkin Engineering Corp.

361—Industrial Semiconductor Products, 12 pp, Motorola Inc.

HYDRAULIC, PNEUMATIC EQUIPMENT

351—Pressure Regulators, 12 pp, Marotta Valve Corp.

355—Tracing Templets for Cylinders, 16 pp, Control Line Equipment

356—Rotary Pumps, 18 pp, Deming Co.

363—Variable-capacity Pumps, 8 pp, Blackmer Pump Co.

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P34	P35	P36	P37	P38	P39	P40	P41	P42	P43
P44	P45	P46	P47	P48	P49	P50	P51	P52	P53

*MULTIPLE Key No.	PRODUCT ADS Specific Product

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P34	P35	P36	P37	P38	P39	P40	P41	P42	P43
P44	P45	P46	P47	P48	P49	P50	P51	P52	P53

*MULTIPLE Key No.	PRODUCT ADS Specific Product

USE THESE PREPAID CARDS FOR

- More information on advertised products
- More data on new materials and components
- Copies of catalogs and bulletins offered
- Free editorial reprints
- Your personal subscription to PRODUCT ENGINEERING

Issue of June 6, 1960
PRODUCT
ENGINEERING
Card expires August 5, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Issue of June 6, 1960
PRODUCT
ENGINEERING
Card expires August 5, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Information Sent Promptly

An Opportunity To Get More Information Quickly, Conveniently

MINNESOTA MR RUBBER

FACTS for FILING on SILICONE

For Unusual Requirements SILICONE is the answer!

Silicone rubber has been found by many designers to be the material needed for their "special" application. Whether you are designing space vehicles, high-performance aircraft components, radar or electronic components, parts for nuclear applications, or seals for use in an automatic transmission or steam iron you too will probably be able to improve your product through the use of silicone. In many of these applications, silicone with its unusual properties is a must.

To make silicone even more useful to designers, Minnesota Rubber fabricates parts by injection molding. This exclusive method of molding produces parts which are completely uniform in all respects. You know exactly what you are getting when you specify silicone parts or extrusions from Minnesota Rubber.

TYPICAL PROPERTIES OF MINNESOTA RUBBER SILICONE COMPOUNDS:

Temperature range	−130 to 500° F
Tensile strength, psi	600 to 900
Tear strength, lb in	40 to 75
Elongation, %	150 to 300
Compression set, % @ 300° F	15 to 40
Hardness range, durometer	20 to 90
Dielectric strength, volts/mil	400 to 500

Oil resistance, depending on oil—good to excellent

FOR MORE INFORMATION ON SILICONE

WRITE: MINNESOTA MR RUBBER

NFPA

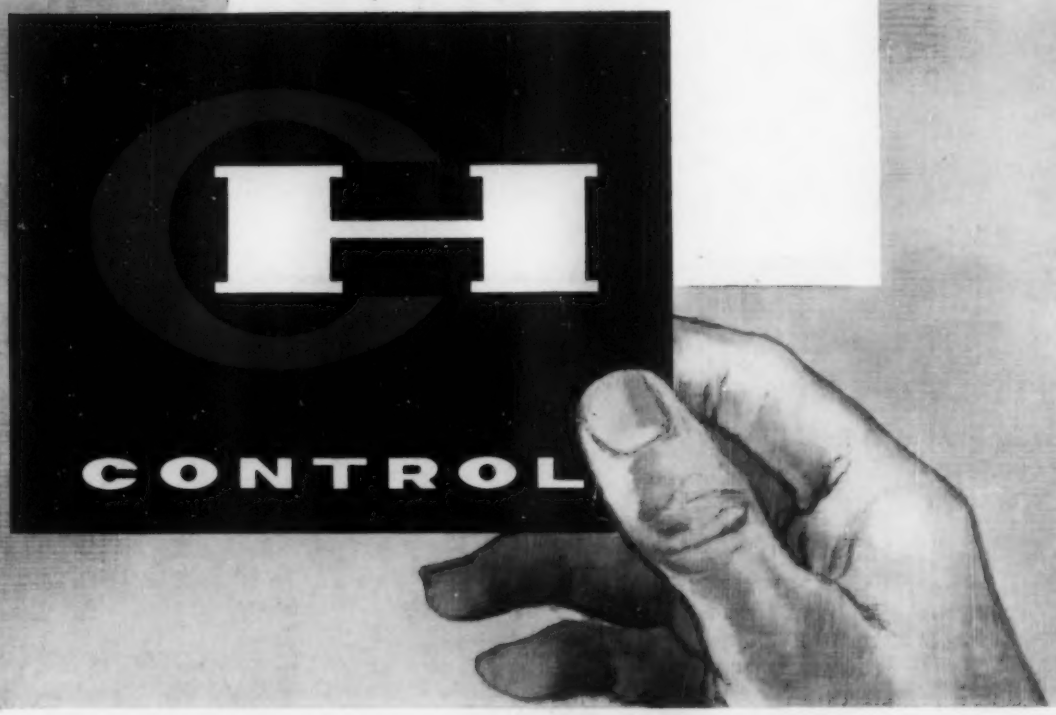
FREE COVER TO BIND YOUR MR "FACTS FOR FILING" PAGES

DEPARTMENT 212 • 3630 WOODDALE AVENUE

MINNEAPOLIS 16, MINNESOTA

CIRCLE 202 ON READER SERVICE CARD

Look what's behind Cutler-Hammer's new trademark



You can see the new power at Cutler-Hammer wherever you look. New products. New engineering depth, particularly in industrial automation. New plants and streamlined marketing methods, too. Even a new trademark to reflect this new vitality.

If you're planning ahead for the great growth of the sixties, come to the company that's ready to plan ahead with you. Look at just a few of the new products that are already improving efficiency in many fields:

NEW computer system for establishing quality of tinplate coils

NEW limit switch that outlasts others by at least two times

NEW automated system for charging blast furnaces in steel mills

NEW stacker that counts and stacks newspapers automatically

NEW Safetybreaker line of service entrance equipment

WHAT'S NEW? ASK...

CUTLER-HAMMER

H CONTROL

Cutler-Hammer Inc., Milwaukee, Wis. • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

CIRCLE 203 ON READER SERVICE CARD